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ABSTRACT

This military-developed text contains four volumes of materials for use in training apprentice still photography specialists. Covered in the individual volumes are the following topics: general subjects (safety and environmental protection); still photographic fundamentals (sensitized black and white film materials, photographic exposure, still motion picture cameras, photographic optics, available and supplemental light, and photographic filters); processing and printing black and white materials (conventional chemistry for black and white photographs; black and white film processing; film finishing, black and white sensitized print material, emulsion printing, and print material processing; and print finishing techniques); and photographic application (principles of photographic composition, reproduction photography, photographic assignments, operating photographic laboratory equipment, color photography, and photographic quality control). Each chapter contains objectives, readings, and criterion test items. Although the volume review exercises have no answers, the questions in them are keyed to the objective numbers for student self-study and review. (MN)

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
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The National Center for Research in Vocational Education
The Ohio State University
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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

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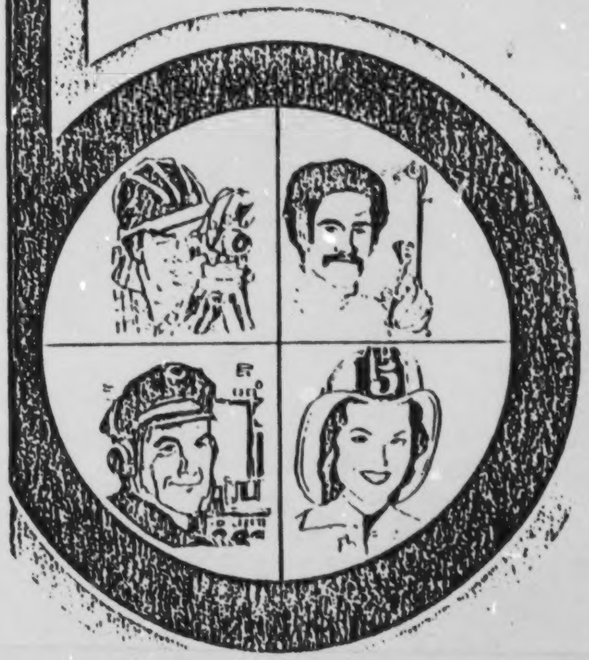

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
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Stillwater, OK 74704
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APPRENTICE STILL PHOTOGRAPHER SPECIALIST

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APPENTICE STILL PHOTOGRAPHER SPECIALIST

Correspondence Course **16-2**

Developed by:

United States Air Force

Development and Review Dates

May, 1975

Occupational Area:

Photography

Cost:

Print Pages:

449

Availability:

Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Suggested Background:

None

Target Audiences:

Grades 10-adult

Organization of Materials:

Text materials with criterion objectives, readings, criterion test items and answers; volume review examinations

Type of Instruction:

Individualized, self-paced

Type of Materials:		**No. of Pages:**	**Average Completion Time:**
Volume 1	– *General Subjects*		Flexible
Volume 2	– *Still Photographic Fundamentals*		Flexible
Volume 3	– *Processing and Printing of Black-and-White Materials*		Flexible
Volume 4	– *Photographic Application*		Flexible

Supplementary Materials Required:

None

Expires July 1, 1978

Course Description

This course was designed to provide the fundamentals of photography for apprentice (semi-skilled) still photographers. A list of duties performed by apprentice photographers follows:

- Prepares for still photographic assignments
- Accomplishes still photography
- Operates still photographic cameras and laboratory equipment
- Processes film
- Accomplishes photographic reproduction
- Mixes and controls chemistry
- Produces prints

This course consists of four volumes organized around criterion objectives with accompanying volume review exercises keyed to the objectives. Some chapters were deleted because they referred to specific military procedures or organization.

Volume 1 — *General Subjects* contains two chapters discussing photographic safety and environmental protection. Five additional chapters were deleted because they deal with military organization and forms.

Volume 2 — *Still Photographic Fundamentals* contains six chapters on sensitized black and white film materials, photographic exposure, still motion picture cameras, photographic optics, available and supplemental light, and photographic filters.

Volume 3 — *Processing and Printing of Black-and-White Materials* contains seven chapters covering conventional chemistry for black-and-white photographs; black-and-white film processing; film finishing; black-and-white sensitized print material, emulsion printing, and print material processing; and print finishing techniques.

Volume 4 — *Photographic Application* contains six chapters covering the principles of photographic composition, reproduction photography, photographic assignments, operating photographic laboratory equipment, color photography, and photographic quality control.

Each chapter contains criterion objectives, readings, and criterion test items. The volume review exercises have no answers, but the questions are keyed to the objective numbers for student self-study and review. This course would best be used in a laboratory or on-the-job learning situation. It provides the fundamentals of still photography, but does not include practice activities.

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CDC 23132

APPRENTICE STILL PHOTOGRAPHIC SPECIALIST

(AFSC 23132)

Volume 1

General Subjects

Extension Course Institute

Air University

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PREPARED BY
DEPARTMENT OF AUDIOVISUAL TRAINING
USAF SCHOOL OF APPLIED AEROSPACE SCIENCES (ATC)
LOWRY AIR FORCE BASE, COLORADO

EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

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Preface

THE FIRST VOLUME of CDC 23132, *Apprentice Still Photographic Specialist*, is designed to help qualify you for the duties and responsibilities of an Air Force apprentice photographic specialist. Volume I contains information on career progression, security, photographic safety, technical publications, supply responsibilities and training, photographic laboratories administration, and environmental protection.

In Chapter 1, you learn about progressing in the Audiovisual Career Field and your duties and responsibilities.

Chapter 2 is devoted to communications security (transmission security). In this chapter you are shown the various types of security classifications, how to deal with certain types of security situations, and how to correct them. We will also cover voice communications and the methods and manner in which classified information is transmitted.

Chapter 3 discusses photographic safety. This chapter covers electrical hazards, chemical safety, and compressed gases. It is extremely important to you since it concerns your physical well-being.

Chapter 4 deals with technical order publications. It covers uses of indexes, technical manuals, and methods of researching commercial publications.

Chapter 5, Supply Responsibilities and Training, points out problems concerning the control of equipment and the training of airmen. This chapter gives you a better understanding of some of the problems your supervisor has to cope with.

Chapter 6 is concerned with photographic laboratories administration and covers copyright and reproduction restrictions, use of forms, planning of missions, and the filing and lettering of negatives.

Chapter 7 concerns the current problem of environmental protection and the attitude of the Air Force to this problem. Silver recovery methods which save a vital national resource are also discussed.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTOC, Lowry AFB CO 80230. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 9 hours (3 points).

Material in this volume is technically accurate, adequate, and current as of May 1975.

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MODIFICATIONS

Chapters 1 and 2 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

CHAPTER 3

Photographic Safety

ACCIDENTS DO NOT happen without cause. Accident records show that of all accidents, 88 percent are caused by unsafe acts of people, 10 percent by unsafe conditions that people allow to exist, and only 2 percent by natural disasters. The identification, isolation, and control of these causes form the backbone of accident prevention programs.

Certain phases of photographic work have a potential for producing accidents. Some of the work is performed in total darkness or under extremely low levels of illumination. Many photographic processes require the use of chemicals that, if used improperly, can cause serious injuries. However, if you are aware of the potential danger, and if you exercise the safety precautions covered in this text, the chances of your being involved in an accident are extremely limited.

You should begin to develop good safety habits now. Accidents result in pain and suffering, needless waste of manpower and materials, and could result in failure to carry out the assigned mission of the unit. For this reason, safety is stressed throughout your training. Protect yourself from possible accidents by paying close attention to the prescribed safety policies and procedures. To do the job right, you must do it safely.

The following text information covering electrical, chemical, compressed gas, and mechanical safety is meant to help you deal with some of the more common safety problems you may encounter.

3-1. Electrical Hazards

In a still photographic facility, you are continuously working with electrical equipment. Although adequate training in equipment operation and proper instruction in safety requirements can help to reduce accidents caused by electricity, there is still the possibility of human error—that incalculable "something" that makes ground safety programs necessary. Often airmen are so thoroughly familiar with their assigned tasks that they become negligent and their negligence results in preventable accidents.

008. Specify the actions that should be taken to reduce electrical hazards.

Many items of equipment used in a photographic facility are electrically powered. To reduce the possibility of electrical shock, burns, and equipment damage when using this equipment, special safety precautions should be taken. For safe operation, you should check power cords for worn or frayed insulation, loose connections, and broken parts. You should regularly check electrical equiment to insure that it is properly grounded. Be sure that all power cords have polarized, three-prong plugs attached. You can reduce the chances of being shocked by removing items of jewelry such as rings, watches, and bracelets before operating machines.

Overloading electrical circuits is extremely dangerous and is not permitted at any time. All systems installed in Air Force installations are equipped with fuses, circuit breakers, or other approved means to prevent accidental overloading. Use only fuses of the proper capacity. Never, under any circumstances, use tinfoil, solder, or other materials in place of a fuse.

To illustrate the care that must be taken to overcome electrical safety hazards, the following schedule of regular inspections of wiring in portable laboratories is given.

Item	Inspection	Period
Electrical Lines	Check for cracks, abrasions, nicks, or cuts.	Every 7 days
Lines, junction boxes, outlets	Check connection for security of attachment, excessive corrosion, or damage that may impair operation or be dangerous to personnel.	Every 7 days
Lines	Check that part numbers on cables are legible or have not been removed.	Every 90 days
Fire extinguishers	Check that seal is not broken. Check that weight is correct. Check that pressure is correct.	Every 180 days Every 180 days Every 180 days

Exercise (008):

1. Which of the following actions should be taken to reduce electrical hazards?

   a. Use polarized, three-prong plugs.
   b. Have personnel wear metal identification bracelets at all times.
   c. Overload circuits.
   d. Use circuit-breakers.
   e. Perform regular inspections.
   f. Use tinfoil as fuses.

3-2. Chemical Safety

Some of the chemicals used in photography are only skin irritants, but others can cause more serious injuries. All chemicals should be regarded as potential poisons and should be handled with caution. Acids and caustic alkalies are dangerous and can cause severe burns if they come into contact with the skin. Some chemicals generate heat and may start fires when in contact with other materials. The following fules are to get you started thinking and practicing chemical safety.

009. From a list of statements, select those that represent correct practices when working with photographic chemicals.

Here are some of the precautions you should take when handling or mixing photographic chemicals:

a. Never smell a chemical directly from the bottle. Instead, hold the bottle at a little distance from your nose and sniff its odor cautiously rather than inhaling deeply.

b. Never taste a chemical.

c. Handle all chemicals cautiously; some can produce burns or skin irritations.

d. When necessary, wear proper protective equipment and clothing. When working with caustic chemicals or acids, wear a rubber apron, rubber gloves, and goggles. If you are mixing powdered chemicals, use a respirator to prevent inhaling the dust.

e. When diluting strong acid with water, add the acid slowly to the water while stirring continuously; otherwise, the solution may boil violently and splatter on your face and hands, causing serious burns. Remember: ALWAYS ADD ACID.

f. Be sure that the chemical mix room or area, where you are going to mix chemicals, is well ventilated. The fumes or dust from some chemicals can be very irritating to your nose and eyes as well as harmful to photographic sensitized materials.

g. Store chemicals in airtight containers in a cool, dry place away from photographic sensitized materials. Chemical fumes and vapors may deteriorate paper and film emulsions. See that chemical containers are properly labeled.

h. If acids, caustic, or toxic chemicals are spilled on a person, remove his clothing, flush the affected parts with copious quantities of water, and get medical help immediately. In the case of ingestion of any type of chemical, seek medical attention immediately. Do not attempt to introduce liquids or to induce vomiting.

Exercise (009):

1. Which of the following statements indicate correct practices of dealing with chemical hazards?

   a. When mixing powdered chemicals, you should wear a respirator.
   b. The best way to identify a chemical is to taste it.
   c. When mixing an acid, you should add the water to the acid.
   d. Chemicals should be stored in airtight containers.
   e. Upon swallowing a chemical, you should seek medical attention.

3-3. Compressed Gases

In some still photographic facilities, compressed gases, such as nitrogen or compressed air, are used daily. Though not lethal in themselves, these compressed gases do pose a special type of safety hazard.

010. Cite two potential safety hazards associated with the use of compressed nitrogen gas.

The most frequently used form of compressed gas is nitrogen. Nitrogen is an odorless, colorless, tasteless, and chemically inert gas which is neither corrosive, explosive, nor flammable. Compressed nitrogen is used for gaseous-burst agitation. (Gaseous-burst agitation requires the release of a burst of nitrogen gas at controlled intervals through a series of tiny holes located in a distributor device placed at the bottom of a processing tank. When correctly monitored and first released, the nitrogen burst imparts a sharp displacement pulse, much like a piston, to the entire processing solution. Then, as the bubbles make their way to the surface of the solution, a localized agitation action is provided around each bubble. By virtue of their great numbers and the random paths made to the surface, the nitrogen bubbles provide effective agitation at the surfaces of film or paper suspended in the solution.)

In some laboratories, cylinders of compressed air are used in equipment having air bearings, air squeegees, or pneumatic systems.

After what has just been said, you might wonder how compressed gas could produce a situation that could be hazardous to you. Actually, it can be dangerous in two ways. First, since it is compressed, there is quite a large volume of gas present in the container. If it is released in a confined area where there is a lack of adequate ventilation, nitrogen gas could easily asphyxiate a worker. Since nitrogen is odorless, colorless, and tasteless, it would be almost impossible to identify the hazardous situation until it was too late. Good ventilation and careful inspection to insure that hoses and fittings are in good condition and properly connected will eliminate this potential hazard.

Secondly, because the gas is compressed, its container is a source of danger. It must be handled carefully to avoid being damaged. If the top is cracked or broken, the escaping gas would turn the cylinder into a deadly projectile. Although accidents occur infrequently, the possibility exists, so remember to handle the gas cylinders with care.

Exercise (010):

1. From the following list, choose the two potential safety hazards associated with compressed nitrogen gas.

   a. The gas could cause asphyxiation.
   b. The cylinder could release lethal gas.
   c. The cylinder could become an unguided missile.
   d. The cylinder could burst into flames.

3-4. Connecting and Disconnecting Tanks of Compressed Gas

At times, it may be necessary for you to disconnect an empty gas cylinder and connect a full cylinder to complete your mission. Therefore, you should know the proper procedures before trying to do this task. The following paragraphs are a summation of the procedures described in TO 42B5-1-2.

011. Indicate the procedures used to connect tanks of compressed gas.

Connecting Tanks of Compressed Gas. The first step in connecting a new gas cylinder is to crack or open the valve slightly. This will blow any dust or debris out of the valve. After re-closing the valve, attach the regulator or union. You must insure that threads on the regulator or union are the same as those on the cylinder valve. If the fittings are hard to turn, do not force them. Check to be certain that the threads are correct and are not damaged. Threads must be of the same type and have the same number of threads per inch to be engageable and to produce a satisfactory seal. After attaching the regulator to the cylinder valve, check to see that the adjusting screw on the regulator is released before opening the

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cylinder valve. When this is done, the lines can be connected to the regulator.

Disconnecting Tanks of Compressed Gas. The procedures for disconnecting tanks of compressed gas are basically the reverse of connecting the tanks. However, cracking the cylinder valve is not necessary.

Exercise (011):

1. List, in sequence, the steps in connecting a compressed gas cylinder.

3-5. Mechanical Safety

With any type of equipment, there is always an inherent safety problem to be coped with. Trimmers have sharp edges that can cut; processing machines have gears that can pinch. The list of potential dangers is limitless. However, an alert individual, following the established safety practices, can avoid becoming a victim of these hazards. Remember, most safety rules are established as a result of someone's unfortunate experience. Don't you provide a reason for making a new rule.

012. Identify conditions, common to all machine operations, that might lead to personal injury.

The following information is to give you ideas for establishing the type of work habits that will reduce the possibility of mishap and injury.

Plan Your Work. The more thoroughly you plan your work, the more likely you are to do it properly and safely. When you perform a task without first planning for it, you usually do many unnecessary operations, make many mistakes, and use many unsafe procedures. Since efficiency and safety are two of your most important considerations, it is essential that you plan your work thoroughly before you do it. During this preoperational planning, you should organize all operations necessary to complete the work properly, efficiently, and safely.

The most important idea to bear in mind when planning a job is to check all pertinent safety instructions. These may concern materials such as protective clothing, machine guards, or the type of equipment you are using. Be sure to study safety instructions carefully, especially if you are doing a job for the first time. As you begin work each day, even on comparatively simple tasks that you are familiar with, plan ahead to be sure all pertinent safety principles are observed. If protective devices are required, have them available.

Discipline Yourself During Work. You know from your basic military training and classroom training how important good discipline is, whether it is in close order drill or in a classroom project. It is even more important when there is a threat to your personal safety. We are not saying that your job is extremely hazardous. It is hazardous only when you don't work safely. That is why you must have discipline.

Just what does good discipline have to do with you and safety on the job? Perhaps we can best illustrate this by an example. Let's say that you are operating a processor. The local operating instructions tell you never to remove the side panels unless the machine is turned off. This is to prevent getting hands or loose clothing caught in moving gears. However, you've done the job so many times that you know you can remove the cover without getting caught in the gears. So you ignore that caution and leave the machine running while removing the cover. Chances are you may get by with it once or maybe several times. However, you are just possibly betting your arm that you can get by with breaking the law of good discipline. You know better, but since "old Sarge" isn't there to enforce the law, you think you can get away with shortening the procedure. You may cheat on safety some of the time, but rarely all of the time, without getting caught. Remember, once may be too often.

Stay Alert. Another basic principle of safety is alertness. Constant alertness is definitely a prime requisite in avoiding accidents. Fundamentally, alertness means paying attention, not just now and then, but all of the time. Unless you pay close attention to what you're doing at all times, you undoubtedly end up doing something wrong; again, you have a situation in which an accident may happen.

The enemies of alertness are external and internal distractions—things that occur outside of you and things that occur inside of you, either mentally or physically.

Perhaps, the most serious disturbances are those that you and your buddies create. It is inexcusable for you or your buddy to do anything that could cause you or someone else to have an accident. This type of external distraction usually takes the form of horseplay.

There are quite a few kinds of internal distractions that may destroy alertness. Whether they are mental or physical, the number of possible internal distractions is just too many to cover in detail. However, let us talk about a couple of them so that we can see the importance of keeping mentally and physically alert while on duty.

A mental distraction is perhaps most often caused by thinking about personal problems rather than concentrating on what you are doing. This violates the principle of alertness. The reason that mental distractions are especially hazardous it that it is impossible for most people to pay attention to more than one thing at a time. Unless you are a rare exception, you had better forget about personal problems while working. If your personal problems are so great that they interfere with your work, let your supervisor know. He may be able to help you solve them. Don't let your personal problems make you cause an accident that damages or hurts somebody. This would create even bigger problems.

Another common mental distraction is daydreaming. This is particularly dangerous, since your mind can become completely absorbed in the pleasantness of a daydream, and your alertness is destroyed. There are very few of us who haven't occasionally been caught napping by a sudden emergency that we otherwise would have seen. Don't permit idle thoughts to destroy alertness. It can cause an accident.

The other kinds of internal distractions are physical. The most prevalent kinds are fatigue, severe pain, and illness. Most of us take care of severe pain and illness, or at least we should. The problem of fatigue cannot always be eliminted. When you become fatigued, you should recognize it and not let it go too far before you inform your supervisor.

Exercise (012):

1. From the following list, identify conditions common to all machine operations that might lead to personal injury.

   a. Organizing work operations.
   b. Planning a camping trip while operating a paper cutter.
   c. Keeping physically fit.
   d. Disregarding operating instructions.
   e. Poor work planning.
   f. Mental distractions.

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MODIFICATIONS

Chapters 4, 5, and 6 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

CHAPTER 7

Environmental Protection

ENVIRONMENTAL pollution is the presence of physical, chemical, and biological elements that adversely affect all living things. Pollution affects human health, alters ecological balances, affects animal and plant life, and causes deterioration of man-made objects. It includes noise, improper solid waste management, and other things conventionally thought of as pollutants.

Pollution is an economic, technical, and social problem. It is a problem because the earth and its inhabitants have only a limited supply of air and water. When these are gone, or contaminated to the point where they can no longer support life, all living things on earth, as we know them, will become extinct. Only recently have we become aware of the consequences of poisoning these two life-sustaining substances. Because of this awareness, much has been done to lay the groundwork for legislation to control water and air pollution.

The Refuse Act of 1899 requires that a permit be obtained before virtually any substance other than sewage is discharged into most streams, rivers, lakes, or other bodies of water. Failure to do so constitutes a criminal offense. Air Force personnel responsible for violating this act can be criminally prosecuted.

The Clean Air Act requires Federal installations to comply with Federal, state, interstate, and local requirements for the control and abatement of air pollution. This is more than just meeting air quality standards. For example, it means that it is necessary to apply for state permits where activities such as fire-fighting training requires state approval.

In this chapter, we discuss the environmental protection program of the Air Force with particular emphasis on photographic facilities. In light of this goal, we also discuss reclaiming silver from fixing baths.

7-1. Environmental Protection Programs

As explained in AFR 19-1, *Pollution Abatement and Environmental Quality*, environmental pollution is the presence of physical, chemical, and biological elements or agents that adversely affect human health or welfare, unfavorably alter ecological balances of importance to human life, adversely affect species of animal or plant life, cause damage to and deterioration of manmade materials or property, or degrade the utility of the environment for aesthetic and recreation purposes. Control of environmental pollution requires consideration of air, water, and land, and must extend to noise, improper solid waste management, and electromagnetic energy, as well as things conventionally thought of as pollutants.

027. From a list of possible environmental practices, identify those which are consistent with Air Force policy.

The Federal Water Pollution Control Act, the Clean Air Act, and other recent Federal legislation require that Federal installations comply with Federal, state, and local legislation covering pollution. The Air Force, therefore, is actively involved in pollution control.

Air Force environmental policy encompasses the following principles:

a. Eliminate or control environmental pollutants generated by or resulting from Air Force operations or from contractor operations on real property owned, leased, or controlled by the Air Force consistent with the overall mission of the Air Force.

b. Lead in preventing, controlling, and abatng environmental pollution by accelerating corrective measures at Air Force installations, and by initiating and supporting local area programs of local communities in developing area-pollution abatement programs.

c. Provide preventive pollution control by: (1) reducing or eliminating waste at the point of generation, (2) considering potential environmental pollution control problems when selecting chemical compounds and material to be used n Air Force operations, and (3) including pollution abatement as an element in specifications.

d. Dispose of discharge pollutants in a manner that will not, directly or indirectly, expose people to concentrations of any substance hazardous to health.

e. Insure that contracts for disposal of waste contain provisions which require the disposal method to be in accordance with applicable local, state, and or Federal criteria and standards.

f. Install facilities or establish procedures to prevent heated water from increasing stream temperatures above acceptable limits.

g. Install treatment facilities where local facilities are not adequate.

h. Insure that all materials (including solid fuels, ashes, petroleum products, and other chemical and biological agents) are used, stored, and handled to avoid or minimize the possibilities of water and air pollution.

The Role of the Base Photo Lab. The base photo laboratory has an important role in carrying out the Air Force's environmental protection policies. The discharge of photographic solutions and waste into the sewage system poses a problem. A laboratory can promote safe disposal by making sure that the photographic solutions and waste are well mixed with water. If large amounts must be discharged, as when processing machines are drained, it would be best to collect the solutions in stand tanks and then control the outflow.

The photographic laboratory makes a vital contribution through the silver recovery program. The regeneration of silver-laden fixing baths and the recovery of silver from black-and-white films saves a vital national resource and reduces the amount of silver-laden waste that is discharged.

Exercise (027):

1. Which of the following practices are consistent with Air Force policy?

   a. Establishment of treatment facilities.
   b. Pollution disposal methods may violate local laws.
   c. Reduction of waste at the point of generation.
   d. Expose local residents to mercury poisioning.
   e. The discharge of large amounts of silver from base photographic operations.

7-2. Silver Recovery Units

The annual production of silver in the United States accounts for only 25 percent of the Nation's industrial requirements. The balance must be obtained through purchase from foreign countries. This has an adverse effect on the Balance of Payments Program. The photographic industry uses approximately 43,000,000 troy ounces (12 troy ounces to a pound) of silver per year. The Air Force is a major consumer of photographic products. Therefore, recovery of silver from expended photographic material is vital in the interest of national economy, conservation of a critical material, environmental protection, and alleviation of the gold flow problem.

Silver is available for recovery from two main sources in the photographic field. One source is various exhausted processing solutions. The other is expended films, papers, and some printed plates.

028. Cite the advantages and disadvantages of equipment used in silver recovery from fixing solutions.

Fixing baths used in black-and-white and color processing are rich sources of silver. The purpose of the fixing bath is to convert unexposed, undeveloped silver halides to water-soluble compounds that can be removed from the emulsion. When black-and-white films are processed, up to 80 percent of the silver in the emulsion dissolves out and remains in solution in the fixing bath. The remainder of the silver forms the image. In color processing, *all* of the metallic silver in the film is converted to a silver salt in the bleach and is removed in the subsequent fixing bath.

Primary Fixers. The primary fixers used in Air Force photographic processing are ammonium thiosulfate and sodium thiosulfate, described thus:

a. Ammonium thiosulfate fixers are exhausted primarily by dilution. Dilution is caused by chemicals carried into the bath by the film and, in turn, fixer ingredients are carried out. The fixing rate of ammonium thiosulfate is affected very little by the silver concentration, so continuous recovery of silver *does not* extend its life. The justification for recovery is the silver itself. Also, with continuous silver recovery, all films enter the wash containing very little residual silver. Since the washing rate is extremely sensitive to the presence of silver, films with low residual silver wash more quickly and have superior archival properties.

b. Films fixed with sodium thiosulfate have wash properties similar to those fixed with ammonium thiosulfate; however, sodium thiosulfate is affected more by silver buildup and is more sensitive to its removal. Continuous silver recovery keeps the fixing time short and, more importantly, increases the fixer life by approximately 50 percent.

Methods of Silver Recovery from Fixer Solutions. There are three primary methods for recovering silver from used fixer solutions. These are electrolytic, metallic replacement, and chemical precipitation.

Electrolytic. In the electrolytic method of recovery, silver is removed from fixing baths by passing a controlled, direct electrical current between two electrodes (a cathode and an anode) that are hung in the solutions. Silver is deposited on the cathode in the form of a nearly pure silver plate. The cathodes are removed periodically, and the silver is stripped off. To maintain the highest efficiency and recovery rates, silver content of the solution and amperage of the electrical current are constantly monitored electronically. This method is the only one that permits reuse of fixer after the silver is removed.

Medium and high-volume processing facilities that generate more than 30 gallons of exhausted hypo solution per 8-hour day (except mobile laboratory facilities) should use an electrolytic recovery unit, such as the one shown in figure 7-1. Activities such as reconnaissance technical squadrons, radiographic laboratories, and base photographic laboratories profit by using this system.

Metallic Replacement. Metallic replacement occurs when a metal, such as iron, comes in contact with a solution containing dissolved ions of a less active metal, such as silver. In this silver recovery system, the dissolved silver ions react with a solid metal, iron. The iron, being the more active metal, goes into solution as an ion, and an ion of the less active silver becomes solid metal.

Although silver ions can displace ions of many of

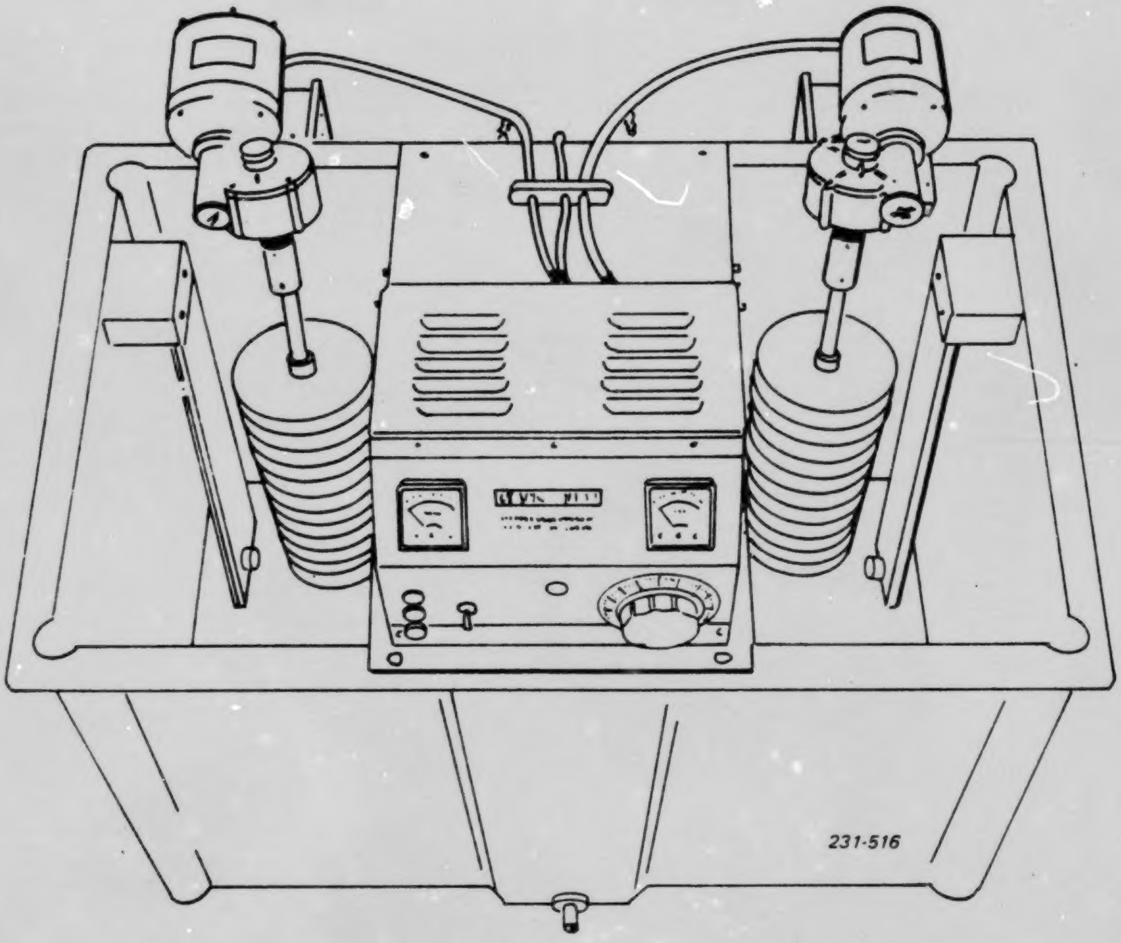

Figure 7-1. Electrolytic Recovery Unit

the common metals from their solid state, zinc and iron are the metals most commonly used to recover silver from fixing baths. Because of its economy and convenience, steel wool is the most often used.

The acidity of the fix is an important factor when you use steel wool to recover silver. Iron dissolves readily in acid solutions, and once it is dissolved, it no longer reacts with silver ions. Too strong an acid solution, therefore, results in the loss of some of the steel wool. However, some dissolution of the iron by the acid fix is desirable because the etching action of the acid exposes new surface area to the solution. Moreover, excess alkalinity slows the replacement reaction.

Fortunately, the pH of most fixes is within the range for good utilization of steel wool. Below a pH of 4, the dissolution of the steel wool is too rapid. Above a pH of 6, the replacement reaction is so slow that an excessive amount of silver may be lost due to the long reaction time required to recover the silver.

After removal of the silver by metallic replacement, the spent fixing bath must be discarded. This effluent is highly contaminated with iron and has no further photographic use.

Since the advent of the chemical recovery cartridge, shown in figure 7-2, the metallic replacement method of reclaiming silver has gained widespread acceptance. The cartridge is easy to use and effective. Fixing solution is pumped through the cartridge and the silver collects on the steel wool. After it becomes laden with silver, the used steel wool can be replaced with fresh. The metallic replacement system is ideal for low volume photographic facilities that generate fewer than 30 gallons of exhausted hypo solution per 8-hour day. These activities include medical and dental X-ray laboratories, photographic hobby shops, and small base photographic laboratories. All mobile facilities can be served by this system.

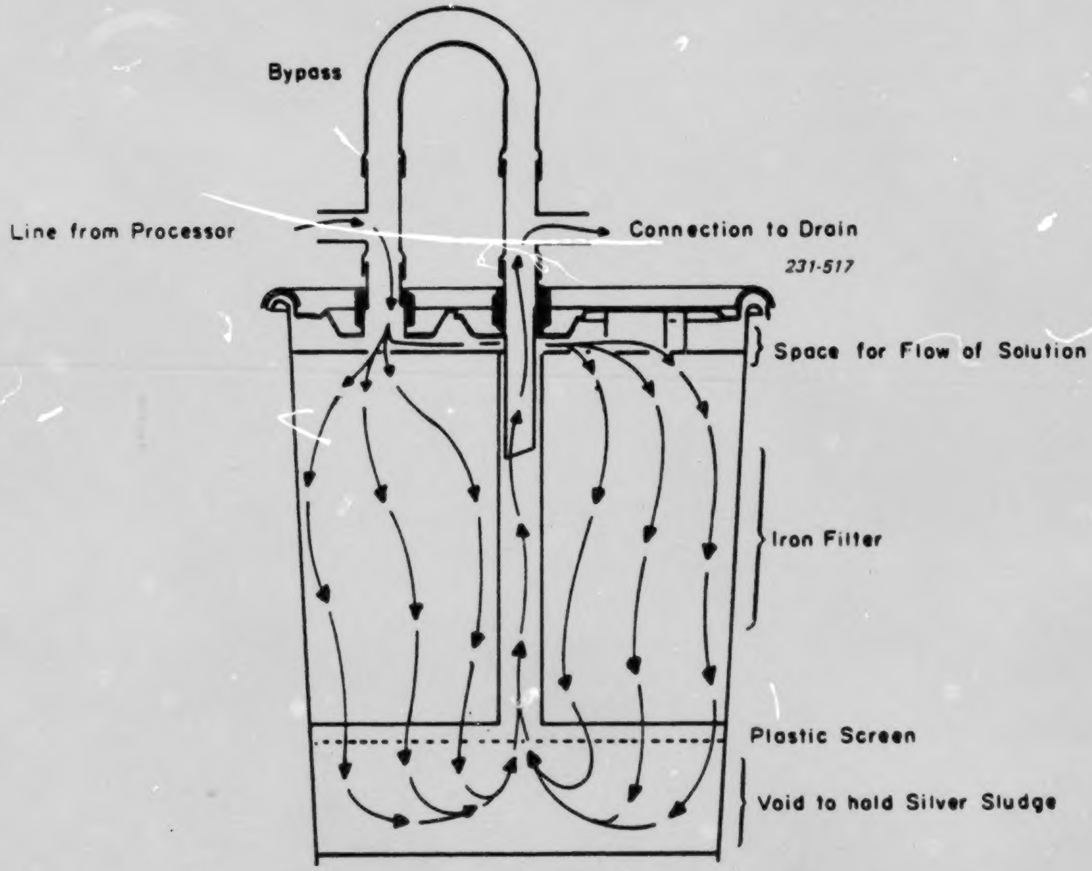

Figure 7-2. Metallic Replacement Cartridge.

Chemical precipitation. By adding certain chemicals such as sodium hydroxide to the solution, silver is precipitated from the fixing bath in the form of sludge which is dried and refined to reclaim the silver. The fixing solution must be discarded after using this method. This method is not recommended for Air Force use due to facility and manpower requirements and because of the noxious fumes and odors it generates.

Exercises (028):

1. Explain the effect that silver recovery has on the two types of fixing baths used in the Air Force.

2. What is the advantage of the electrolytic method of silver recovery?

3. Under what conditions is the metallic replacement method ideal?

4. What are the drawbacks in the chemical precipitation method?

029. Identify the methods that can be used to recover silver from black-and-white film.

Methods of Silver Recovery from Black-and-White Film. There are currently two methods for recovering silver from processed and unprocessed film and paper remnants. These are:

Incineration. In this method, the film is reduced to ash under controlled conditions. The material is placed in a burner to control temperature not to exceed 1,700° Fahrenheit, since higher temperatures bring about vaporization of the silver. To comply with pollution abatement standards, control of emission is also essential. After it is recovered, the ash is further refined by smelting.

Emulsion stripping. Film strippers are designed to remove the residual silver from photographic negative, sheet, or rollfilm base. The strippers utilize a chemical solution which converts the silver in the emulsion back to a halide state. This method is generally considered more expensive than reducing the film to ash, but it has the advantage of conserving the film base for reuse or sale.

Exercise (029):

1. What two methods are used to recover silver from black-and-white film?

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ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

001 - 1. b. c. d.

002 - 1. 1. b. 2. a. 3. e. 4. d. 5. c.

003 - 1. 3 level.
003 - 2. 5 level.
003 - 3. 7 level.

CHAPTER 2

004 - 1. a. Classified.
  b. Unclassified.
  c. For Official Use Only.
  d. Unclassified but of possible intelligence value.

005 - 1. a. TOP SECRET.
  b. SECRET.
  c. CONFIDENTIAL.
  d. CONFIDENTIAL.
  e. FOR OFFICIAL USE ONLY.

006 - 1. a. Messenger.
  b. Encrypted radio message.
  c. Registered mail.

007 - 1. a. Poor physical security.
  b. Poor planning.
  c. Awe of rank.
  d. Talk around, paraphrasing, incomplete references, self-made reference system.

CHAPTER 3

008 - 1. a. d. e.

009 - 2. a. d. e.
010 - 1. a. c.

010 - 1. Crack the valve; re-close valve; attach the regulator; check the adjusting screw on the regulator and make certain that it is released before opening the cylinder valve; connect lines to the regulator.

012 - 1. b. d. e. f.

CHAPTER 4

013 - 1. 1. d. 2. a. 3. b. 4. c.

014 - 1. 10E8-2-5-11: 10 = Photographic Equipment, Supplies, and Sensitized Materials Technical Orders; E = Processing Equipment; 2 = Contact (Manual) Printers; 5 = Type A-14a (Morse); 11 = Operation and Service Instructions.

015 - 1. Damage to equipment and mission failure.

CHAPTER 5

016 - 1. AF Form 601b, Custodian Request Receipt, is used to request equipment through normal supply channels and for turning in unserviceable equipment.
AF Form 1297, Temporary Issue Receipt, is used to check out nonexpendable supplies for a unit supply.

017 - 1. Provides a listing of the type and quantity of equipment authorized for different types and sizes of operations. The "allowances" therefore form the basic requirements for a unit.

018 - 1. When property valued at less than $250 is lost and the individual who is responsible admits liability but cannot pay for it. The statement of charges authorizes the Air Force to take the amount due from the person's pay.

019 - 1. When property valued at $250 or more is lost or when the charged individual does not admit liability.

020 - 1. Transition training, contract special training, and ATC Special Resident training.
020 - 2. AFM 50-5 is the *USAF Formal Schools Catalog*. The catalog's two volumes give information related to all training courses conducted by the Air Force.

CHAPTER 6

021 - 1. e. g. h. j.
021 - 2. a. Mental.
  b. Federal.
  c. Regulations.
  d. Unpublished.
  e. Civil; criminal.

022 - 1. a. They identify the task to be performed, explain the reasons for performing the task, place the responsibility for performance, and outline the procedure for performance.
  b. Contains the step-by-step written record of the job from the request through the production steps and the delivery.
  c. Process control charts are used to help maintain quality control.

023 - 1. a. b. c. d. e.

024 - 1. a. b. e.

025 - 1. a. Still photographic documentation.
  b. Number, calendar year, unit, and classification.
  c. Acetate (base).
  d. The identification number, classification caption, and credit line.

026 - 1. a. Filed or forwarded.
  b. CONFIDENTIAL.
  c. Negative file ledger.

CHAPTER 7

027 - 1. a. c.

028 - 1. An ammonium thiosulfate fixing bath is exhausted primarily by dilution. Silver recovery, therefore, does

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not extend its life. A sodium thiosulfate fixer is sensitive to silver buildup; therefore, silver recovery does extend its life.

028 - 2. Unlike other methods, the electrolytic method permits reuse of the fixing bath.

028 - 3. Low volume photographic facilities that generate fewer than 30 gallons of exhausted hypo solution per 8-hour day.

028 - 4. Chemical precipitation requires special facilities and manpower requirements. This method also generates noxious fumes and odors.

029 - 1. Incineration and emulsion stripping.

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STOP–

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 1 OR NUMBER 2 PENCIL.

23132 01 21

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
GENERAL SUBJECTS

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that numerical sequence on answer sheet alternates across from column to column.
3. Use a medium sharp #1 or #2 black lead pencil for marking answer sheet.
4. Circle the correct answer in this test booklet. After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'TS:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #1 or #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed*. Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

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Multiple Choice

1. (001) All of the following methods may be used to achieve AFSC 23132 except

   a. passing the apprentice knowledge test.
   b. completing the Basic Still Photographic Course.
   c. completing the By-Pass Career Development Course.
   d. receiving upgrade training.

2. (001) Job proficiency and job knowledge make up

   a. the "Dual-Channel Concept" of upgrade training.
   b. a career development course.
   c. on-the-job training.
   d. the apprentice knowledge test.

3. (002) A chief master sergeant in still photography would have which of the following AFSCs?

   a. 23190.
   b. 23172.
   c. 23152.
   d. 23192.

4. (003) According to the specialty description, all of the following would be performed by 3 and 5 level still photographic workers except for

   a. the processing of film.
   b. the lighting of copy setups.
   c. performing quality control.
   d. the mixing and controlling of photo chemistry.

5. (004) Official information is divided into which two broad categories?

   a. Classified and unclassified information.
   b. CONFIDENTIAL and Unconfidential information.
   c. SECRET and For Official Use Only.
   d. CONFIDENTIAL and Of Possible Intelligence Value.

6. (005) Exceptionally grave damage to the national security could result from the unauthorized disclosure of

   a. SECRET information.
   b. TOP SECRET information.
   c. CONFIDENTIAL information.
   d. information Of Possible Intelligence Value.

7. (005) Serious damage to the national security could result from the unauthorized disclosure of what level of classified information?

   a. SECRET.
   b. TOP SECRET.
   c. CONFIDENTIAL.
   d. Information Of Possible Intelligence Value.

8. (006) A mode of communication that is reliable is one where

   a. there is little chance of compromise.
   b. the time it takes to send out the message is minimized.
   c. there is no chance for "bugging."
   d. there is a guarantee that the message will reach the right person.

9. (006) Each of the following modes of communication can be used to transmit classified information except

a. mail.
b. messenger.
c. the telephone.
d. the radio.

10. (006) Mail can not be used to transmit what type of information?

a. TOP SECRET.
b. SECRET.
c. CONFIDENTIAL.
d. Information Of Possible Intelligence Value.

11. (007) If you refer to a classified piece of electronics as that "big black box" when on the telephone, you are trying to discuss classified information by using

a. "paraphrasing."
b. "talk around."
c. "partial reference."
d. "code words."

12. (008) All of the following should be used to reduce electrical hazards except

a. circuit breakers.
b. three-prong plugs.
c. tinfoil fuses.
d. grounded electrical equipment.

13. (009) When mixing a strong acid and water, you should always

a. add the water to the acid.
b. simultaneously pour the acid and water into a container.
c. add the acid slowly to the water.
d. heat the water to a boiling temperature prior to pouring it into the acid.

14. (009) Chemicals should be stored in airtight containers

a. in open storage tanks.
b. in a warm, humid environment.
c. next to sensitized material so it is always available.
d. in a cool, dry place.

15. (010) All of the following characteristics apply to compressed nitrogen gas except that it

a. can cause asphyxiation.
b. is colorless.
c. is ordorless.
d. is flammable.

16. (011) The first step in connecting a new gas cylinder is to

a. hook up the regulator to the union.
b. release the adjusting screw.
c. crack the valve.
d. connect the lines to the regulator.

17. (012) All of the following can help you reduce accidents except

a. planning your work.
b. self-discipline.
c. alertness.
d. daydreaming.

18. (012) The reason that mental distractions are so hazardous is that we

a. neglect to seek counsel and advice for our problems.
b. tend to become mentally fatigued.
c. become irritable and impatient.
d. can generally pay attention to only one thing at a time.

19. (013) There are a number of indexes to technical orders and manuals, but the one you will be most concerned with is

a. 0-1-01.
b. 0-2-1.
c. 0-3-1.
d. 0-4-1.

20. (013) The numerical index for photo technical orders is

a. 0-4-1.
b. 0-1-10.
c. 0-1-1-1.
d. 0-1-01.

21. (013) When only the type of equipment is known, it is best to look up the applicable technical order in the

a. Numerical Index and Requirement Table.
b. index type technical order.
c. alphabetical index.
d. cross-reference tables index.

22. (014) In technical order number 10E8-2-19-4, the number 10 indicates the

a. technical order category.
b. major group of publications.
c. specific item of equipment.
d. type of publication.

23. (014) Sensitized materials and supplies are found in which major group of technical publications?

a. 10M.
b. 10J.
c. 10E.
d. 10B.

24. (015) Reading commercial texts will help you prevent all of the following except for

a. wrong exposures.
b. wrong processing times.
c. material defects.
d. mission failures.

25. (016) Which Air Force form is used to dispose of obsolete or unneeded items?

a. 67-1.
b. 601b.
c. 629.
d. 1297.

26. (016) Which Air Force form is used for the temporary issue of nonexpendable supplies?

a. 09.
b. 601b.
c. 1205.
d. 1297.

27. (017) To determine what equipment is authorized for your photo laboratory, you should consult the

a. numerical equipment index.
b. tables of allowance.
c. applicable technical orders.
d. photographic laboratory index.

28. (018) Any time you acquire an item of Air Force property, you have

a. no direct responsibility for the item.
b. a supervisory responsibility.
c. a custodial responsibility.
d. a supply responsibility.

29. (018) Pecuniary liability for loss or damage of Air Force property is outlined in

a. AFR 0-9.
b. AFR 0-10.
c. AFR 11-31.
d. AFR 67-10.

30. (019) A report of survey is conducted

a. when the lost or damaged equipment cost less than $40.
b. only when the person was negligent.
c. when time permits.
d. when the person who has lost or damaged equipment denies pecuniary liability.

31. (020) What type of training would be given to qualify skilled personnel on new or different types of equipment associated with their AFSCs?

a. Transition training.
b. Familiarization training.
c. Proficiency training.
d. Qualification training.

32. (020) All of the following are examples of Air Force special training except

a. retraining into a different career field.
b. contract training.
c. Air Training Command Special Resident Training.
d. on-the-job training.

33. (020) To determine what training is available, you should consult

a. AFM 12-97.
b. AFM 50-5.
c. AFR 52-2.
d. AFR 67-10.

34. (021) Whthin the United States, copyright protection is obtained from the

a. state where the artist lives.
b. United Nations.
c. person or corporation who buys the work.
d. Federal Government.

35. (021) Which Air Force regulation covers the procedures regarding printing, duplication, and copying?

a. AFR 6-1.
b. AFR 50-5.
c. AFR 52-5.
d. AFR 36-93.

36. (021) Which of the following can be copied to the same size and in color?

a. Stamps.
b. Coins.
c. Checks.
d. Paper money.

37. (022) Complete procedures to be followed in performing a task are likely to be found in

a. work orders.
b. operating instructions.
c. quality control forms.
d. routing slips.

38. (023) All of the following are considered during mission planning except

a. tables of allowance.
b. work priorities.
c. security.
d. selection of equipment.

39. (024) Each of the following types of information would be useful to record during a mission except to list

a. the size and type of the film.
b. all of the technical data.
c. the time expended in setting up equipment.
d. the subject matter.

40. (025) Still photography documentation as part of the Air Force mission should do each of the following except to

a. depict significant functions and activities of all major commands and command level agencies.
b. provide a visual history of the Air Force.
c. provide good quality photographs of key personnel.
d. provide a continuous visual account of the day-to-day activities of an organization.

41. (025) The Audiovisual Records Disposition Program is covered in

a. AFR 398-2.
b. AFR 205-1.
c. AFM 107-10.
d. AFR 95-4.

42. (025) Each of the following is lettered on a negative except for the

a. calendar year.
b. security classification.
c. photographer's name.
d. exposing unit.

43. (025) Each of the following is lettered or printed on a release print except for the

a. caption data.
b. classification.
c. credit line.
d. exposure setting.

44. (026) Which of the following types of negatives would normally be filed?

a. Copy negatives that satisfy the needs of one user.
b. Combat documentation.
c. Negatives of recreational subjects.
d. Negatives of poor technical quality.

45. (027) Which of the following practices is not consistent with Air Force environmental policies?

a. That contracts for the disposal of waste meet local laws.
b. Installation of treatment facilities.
c. Insuring that all chemicals are dumped into bodies of water.
d. Support of local environmental programs.

46. (028) Silver recovery improves the fixer life of which of the following chemical solutions?

a. Sodium carbonate.
b. Sodium thiosulfate.
c. Potassium bromide.
d. Ammonium thiosulfate.

47. (028) Silver is recovered from all of the following photographic sources except

    a. black-and-white film.
    b. fixing baths used in color processing.
    c. fixing baths used in black-and-white processing.
    d. color film.

48. (028) Which of the following is a primary method of recovering silver?

    a. Chemical distillation.
    b. Metallic recipitation.
    c. Chemical precipitation.
    d. Metallic abstraction.

49. (028) Through which of the following means has the metallic replacement method of reclaiming silver been given widespread acceptance?

    a. By using the chemical recovery cartridge.
    b. By adding sodium hydroxide to the fixing solution.
    c. By using a chemically dissolved ionized copper plate.
    d. By adding an alkaline solution to the fix.

50. (029) Which of the following is one of the methods of silver recovery from unprocessed film and paper remnants?

    a. Shredding.
    b. Incineration.
    c. Chemical evaporation.
    d. Chemical distillation.

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23132 02 7510

CDC 23132

APPRENTICE STILL PHOTOGRAPHIC SPECIALIST

(AFSC 23132)

Volume 2

Still Photographic Fundamentals

Extension Course Institute

Air University

Preface

THIS SECOND of four volumes is designed to help you qualify as an Apprentice Still Photographic Specialist. Volume 2 contains information on black and white films, exposure, camera systems, optics, lighting, and filters.

Chapter 1 discusses various black-and-white film emulsions, the criteria for the selection of film emulsions, and the methods and procedures used for the proper storage and preservation of unexposed black and white films.

In Chapter 2 we cover the theory of photographic exposure and the various devices, and the procedures that are used to measure and calculate the brightness of a scene to determine proper exposure.

Chapter 3 covers the operation of reflex cameras, press and view cameras, copy and duplicating cameras, 35mm SLR/RF cameras, and motion picture cameras.

Chapter 4 is devoted to photographic optics. In this chapter we cover such items as principles of photographic lenses, lens types and their effects, and the use of lenses for image control.

Chapter 5 is devoted to lighting. We delve into what might be considered the keystone of photography—light. Just as the talent of an artist is reflected in the delicate hues and shading of oil colors on his painting, so, too, the professionalism that a photographer exhibits is marked by the manner in which he uses light. By intelligent use of various lights and light sources, his photographs can be made to reflect the desired mood, style, and impact.

Chapter 6 provides information on photographic filters. Many photographers think filters are used only to emphasize clouds in black-and-white pictures. But filters have many more uses, in both black-and-white and color photography. This chapter covers the theory of filter use as it applies to black-and-white work.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTOX, Lowry AFB CO 80230. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 27 hours (9 points).

Material in this volume is technically accurate, adequate, and current as of July 1975.

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2 Photographic Exposure 16

3 Still/Motion Picture Cameras 30

4 Photographic Optics 76

5 Available and Supplemental Light 91

6 Photographic Filters 107

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Answers for Exercises 121

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Sensitized Black-and-White Film Materials

THIS CHAPTER will acquaint you with the physical structure and emulsion characteristics of black-and-white film. There are many types of black-and-white sensitized materials (film) available for your use. Some of the differences between these films are very important. Quality photographic results depend on your knowing and taking advantage of these differences. When you are aware of the differences in various types of film, you can make an intelligent choice to obtain a desired result. Even with the simplest of cameras, a change in film may improve the final product.

1-1. Structure

All conventional photographic films consist of several layers. Each layer is made of a given material to serve a specific function. These layers are: the overcoating, the emulsion coating, the substratum coatings, film base, and antihalation backing. Refer to figure 1-1. We discuss the function of each of these layers.

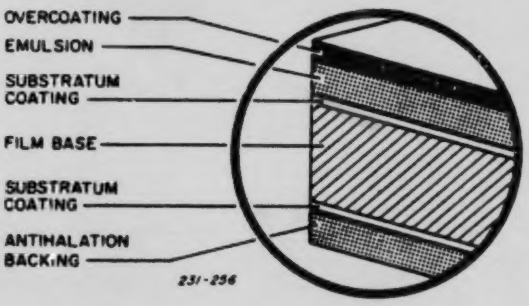


Figure 1-1. Structure of film emulsion.

200. Complete sentences about the functions and characteristics of various layers in the structure of film.

The Overcoating. The overcoating is a thin layer of gelatin that protects the emulsion beneath it during normal handling and use of the material. Without this protective overcoating, the mere act of placing films on top of one another would be sufficient to cause minor scratch and abrasion marks which would show up after processing. However, this overcoating cannot protect the emulsion from rough or abusive handling.

The Emulsion Coating. The emulsion coating is a light-sensitive layer consisting of millions of microscopic silver halide particles imbedded and suspended in gelatin. The characteristics of the emulsion are determined by the kind and combination of silver halides, the size of the silver halides, how evenly distributed they are in the gelatin, and the addition of dyes and other chemicals in the emulsion, and the quality of the gelatin itself. The emulsion, therefore, gives the film its basic characteristics.

The Substratum Coatings. The emulsion gelatin containing the light-sensitive particles does not adhere to the base without some kind of bonding material. A coating, spread over the base, provides the bond between the base and the emulsion. There are two coatings—one on each side of the film base. The bonding coat is a very exact formula consisting of a cellulose acetate solvent, gelatin, and a gelatin solvent. These bind the emulsion coating and the antihalation coating firmly to the film base.

The Film Base. At one time the only support used for negative emulsions was glass. But since glass plates were heavy, bulky, and easily broken, photography was limited to professional use. (Glass plates are still used in many scientific applications of photography.) Eventually, research proved *cellulose nitrate* to be a suitable base material for the emulsion layer. It was light in weight, chemically inert (not affected by processing), transparent when free from impurities, and flexible (characteristics essential for common films). However, it had the tremendous disadvantage of being flammable. It would burn with almost explosive force. Film manufacture has now progressed to give us fire-resistant plastic base materials, such as cellulose acetate, with great resistance to shrinkage and tearing.

The Antihalation Backing. The antihalation backing is usually a layer of dyed gelatin on the back side of the film. This backing serves two purposes, one of which is to counteract the curling tendencies of the film due to the contraction of the emulsion layer when it sets and dries. This helps the film to lie flatter in the sheet film holders and also makes it easier to handle when printing. The other purpose is to absorb as much light as possible which goes through the film during the exposure. This light would otherwise be reflected back into the emulsion layer causing a halo around the images of brilliant subjects. Such unwanted effects are called *halation.*

Black antihalation dyes are more effective than dyes of other colors, but normal processes make their use impractical. Ordinary processing solutions are unable to destroy the black dyes which have been discovered so far. (There is an exception in the graphic arts field that requires a special developing solution.) Until a black dye is developed that can be destroyed in the processing solutions, we must use dyes of a color to which the film is least sensitive, or use a dye that absorbs as much as possible the unwanted light that causes halation.

Exercise (200):

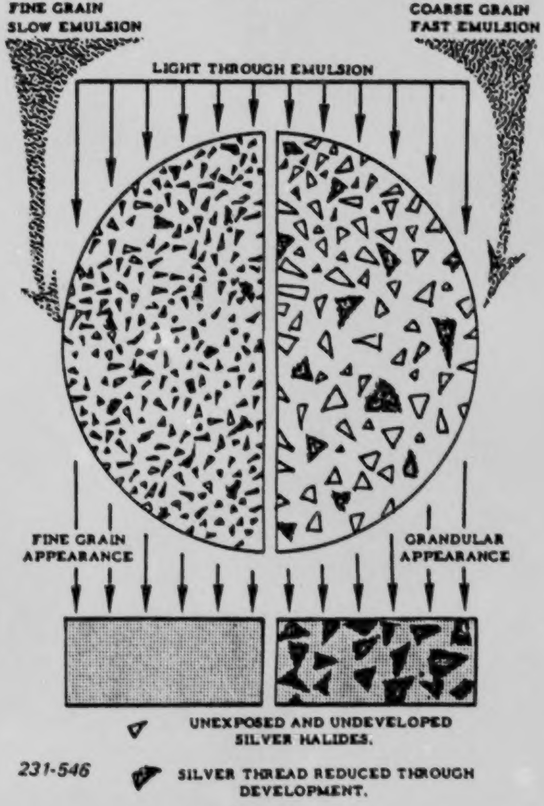
1. Complete the following statements regarding the structure of film.
   a. The ____________ protects the film from minor scratches.
   b. The photographic image is formed in the ____________________ .
   c. There are ______________ substratum coatings.
   d. Glass and cellulose acetate are materials that can be used to make the ____________ ________________ .
   e. The antihalation backing is used to prevent ____________ and ______________ .

1-2. Grain

A photographic emulsion contains microscopic particles (grains) of silver halide. Because of certain processes during manufacturing, these grains have a tendency to clump together. This clumping characteristic determines the inherent (natural) size of the grain in any film.

201. Complete sentences about film grain size.

High-speed (very sensitive to light) emulsions generally have a larger grain than slow-speed emulsions. The tendency of a


FINE GRAIN SLOW EMULSION
COARSE GRAIN FAST EMULSION
LIGHT THROUGH EMULSION
FINE GRAIN APPEARANCE
GRANDULAR APPEARANCE
UNEXPOSED AND UNDEVELOPED SILVER HALIDES.
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SILVER THREAD REDUCED THROUGH DEVELOPMENT.

Figure 1-2. Size of silver halides.

particular film to produce a certain size of grain is called the inherent grain size.

Although inherent grain size influences the graininess of the image, processing also has a great effect in the control of graininess. By special processing techniques, it is possible to prevent the silver grains from excessive clumping during processing. When the grain becomes apparent in the image, it is objectionable.

When a print is made, it sometimes has a grainy appearance, especially in the large middle tone areas. This is caused by the granularity of the film being printed. Thus, the grain structure of the film influences the final product and therefore must be considered.

Remember, the faster the speed of the film, the more uneven is the distribution of large and small crystals of silver halide in the emulsion. The silver halides, when developed, form little threads of metallic silver which reach out into the surrounding gelatin. It is the overlapping of these silver threads that help give the appearance of clumping and grain. Figure 1-2 shows a comparison between a slow and fast film as if you were looking at them edgewise through an electronic microscope. Notice how the evenly distributed silver halides in the slow emulsion do not cast shadows on each other so readily at each level; and since the clumping of grain is not apparent in the structure of this emulsion, it is called "fine grain."

Exercise (201):

1. Complete the following statements regarding film grain.
   a. Grain size is determined to a large degree by the choice of __________ and the type of ______________.
   b. In a print, the grain will appear most prominently in the ________ ________.
   c. Fine grain films have ___________ film speeds and very ____________ distribution of silver.

1-3 Sensitivity and Latitude

The many and varied applications of light-sensitive materials are due to the behavior of the individual silver particles (silver halide crystals) that are suspended in the emulsion. The silver halides in negative materials are extremely sensitive to light, and they can store up the action of a very small amount of light.

202. State selected definitions and factors related to the sensitivity of film.

Energy due to radiation is absorbed in very small amounts. The amount of effective energy varies directly with the frequency of the light. The short wavelengths have the highest frequencies, hence the shorter wavelengths are more energetic than longer wavelengths. The light-sensitive silver compounds absorb varying amounts of this energy within certain ranges. Therefore, the reaction of the emulsion to light energy absorbed varies with the frequency. Since the colors of visible light change with frequency changes, the various emulsions are named or graded according to their response to different colors of light. Some emulsions react to a wide range of wavelengths, whereas others are affected only by a narrow band of wavelengths. The reaction of the emulsion to different colors is termed color sensitivity.

The normal sensitivity of a silver halide in an ordinarily prepared emulsion is limited to the ultraviolet, violet, and blue wavelengths. All silver halides are insensitive to green, yellow, and red. Consequently, the pure silver halide emulsions are termed blue sensitive. They reproduce colored objects in a different tonal brightness range than seen by the eye.

The addition of photographic sensitizing dyes (cyanides) to ordinary silver halide emulsions has increased their sensitivity to approximately the same spectral region as that of the eye. Increasing the emulsion's sensitivity to light of longer wavelengths by dyeing (staining the silver halide crystals) is called optical sensitization. The increased sensitivity gained through the normal emulsion ripening process should not be confused with optical sensitization, since the latter is only the spectral sensitivity of the silver halides. Optically sensitized emulsions are prepared by adding the sensitizing dyes in solution to the ripened emulsion just prior to coating it onto the base.

When the pure silver halide emulsion is exposed to long wavelength radiations, no energy is absorbed to any developable degree, and no change is induced in the silver halide crystals. The function of the sensitizing dyes is to absorb the longer wavelengths and to transfer the effect to the silver halide. This produces the same action as direct absorption of light.

As a photographer, your primary interest in optically sensitized emulsions is in the added sensitivity beyond that of the unsensitized emulsion. This type of sensitization may be

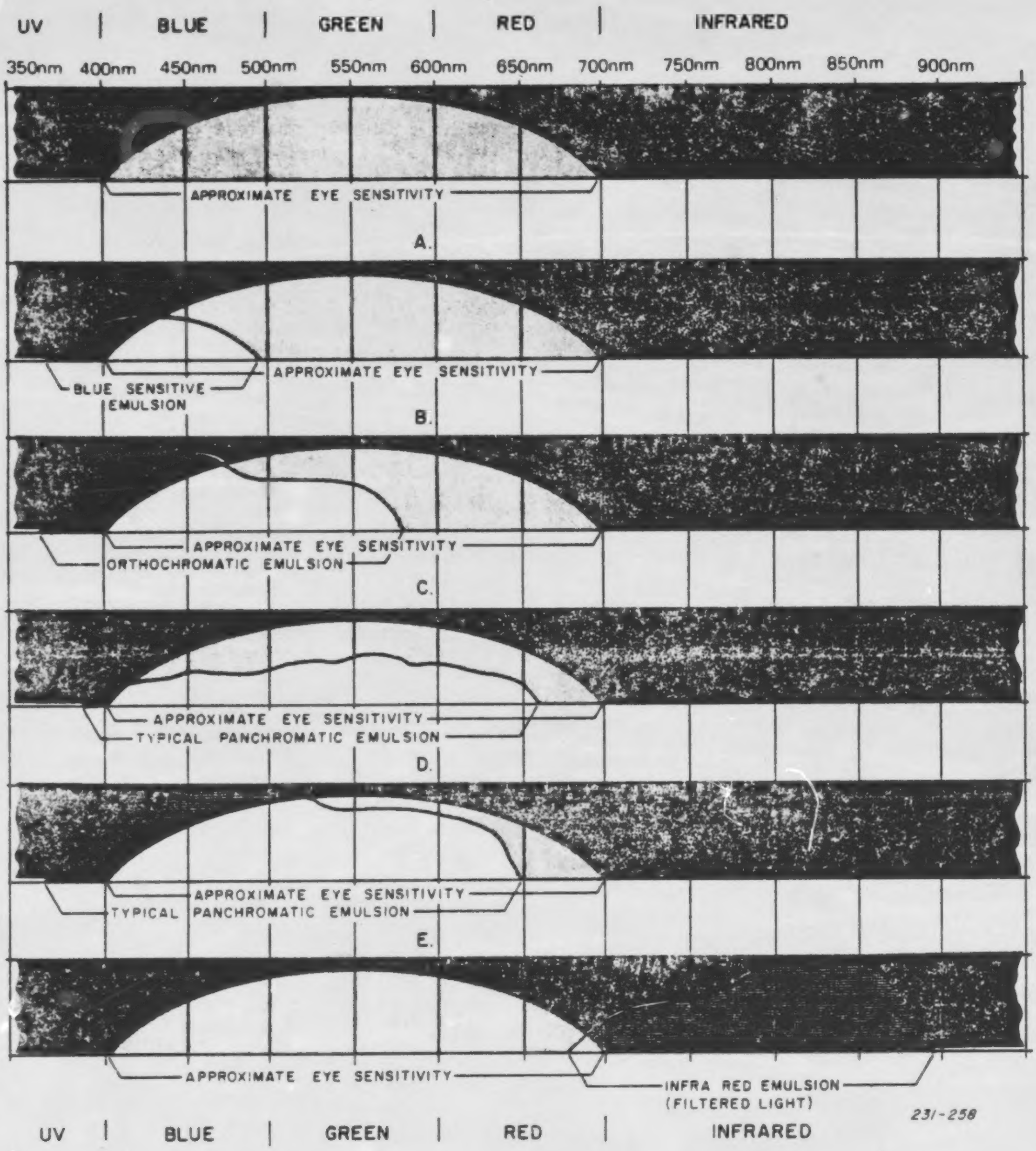

Figure 1-3. Color sensitivity of film.

obtained over a wide range of the spectrum by adding mixtures of sensitizing dyes, each of which sensitizes strongly at different wavelengths. For some types of photography an emulsion having a high sensitivity to a narrow band of the spectral region is advantageous. For example, this type of sensitivity is desirable for infrared photography. By using suitable dyes, modern emulsions can be rendered sensitive to all wavelengths from the normal absorption bands of a silver halide, throughout the visible spectrum, and far into the infrared region. The different types of emulsions in use and their individual spectral sensitivity differences are discussed in the following sections of this chapter.

The response of light-sensitive materials to the various radiant energy wavelengths is called *spectral sensitivity* or *color sensitivity*.

Color sensitivity is a very important characteristic of negative materials. Since it determines to a large extent the tones in which colored objects are reproduced, it is most important that you know the color sensitivity of various light-sensitive materials. Figure 1-3 graphically illustrates the sensitivity of black-and-white negative material to different wavelengths of light.

The normal human eye response to light, in terms of wavelengths, ranges from approximately 400 to 700 nanometers. That is, its sensitivity begins in the violet region and extends through blue, green, and red regions. However, the sensitivity of the eye is not the same for all wavelengths. Part A of figure 1-3 is a graphic curve that represents the relative response of the eye. It shows that the eye has maximum sensitivity in the blue-green and yellow-green portions of the curve.

Compared to the eye, films may respond differently to light. Negative emulsions are classified into four general types according to the way in which they render color differences as brightness differences. These four classifications are: blue sensitive, orthochromatic (sensitive to blue and green), panchromatic (sensitive to all the visible colors), and infrared emulsions (sensitive to blue, red, and part of the longer wavelengths beyond red). All silver halides, it should be recalled, are sensitive to ultraviolet radiation.

Exercises (202):

1. Why are shorter wavelengths of light more energetic?

2. The reaction of the emulsion to light varies with what quality of light?

3. All silver halides are sensitive to what wavelengths of light?

4. Define optical sensitization.

5. What type of film has color sensitivity similar to that of the human eye?

203. Define film latitude and identify it with particular film characteristics.

The ability of a film emulsion to record a range of subject brightness values (range of reflected light from the highlights through the shadows) is called *film latitude.* The range of brightness values in the scene that end up on a negative or a print as shades of gray may be very great, but if an emulsion is capable of rendering a long range of brightness values with satisfactory tone separation, it has *wide latitude.* Conversely, if an emulsion can produce only a short range of brightness values it has *little latitude.* These differences in film performance determine the film's *inherent latitude.*

Inherent latitude is often considered to be an exposure safety factor. The extent that the exposure can deviate from normal and still give you an acceptable image is known as *exposure latitude.* Exposure latitude is directly proportional to film latitude. If you have film with wide latitude, you have wide exposure latitude. In general, latitude in black-and-white films is related to film speed, with the faster speed films having greater latitude. Exposure latitude permits you, the photographer, to use several possible exposures and still render printable negatives. As long as the range of tones in the scene maintain their same relationship, your exposure is correct insofar as latitude is concerned.

Exercises (203):

1. Define film latitude.

2. Exposure latitude is directly related to what factor?

3. Latitude in black-and-white film is related to what film characteristic?

1-4. Speed

Film speed is a term that is sometimes misunderstood. Simply stated, however, it means that some films are affected by light much more quickly than others. Film manufacturers have assigned a speed number to each film. The higher this number, the faster the film. The biggest advantage of knowing the film-speed number is that it allows you to make a comparison between the speed of one film and another. For example, if a film has a number double that of another, it means that it is twice as fast. Or stating the idea another way, it means that only half the amount of light is required to affect the faster film to the same degree.

204. Identify the organization that establishes procedures for determining film speed and complete statements that apply to film speed.

Emulsion speed is a photographic property of very practical importance to you because it has a direct bearing on the exposure required to produce a good image with photographic materials. To assist you, all exposure computation devices (whether they are exposure meters or exposure guides) are calibrated to the film-speed number system. The American National Standards Institute (ANSI) establishes procedures for determining the speed of sensitized materials so that rating systems are standardized. The manufacturer's data sheet includes the speed rating expressed in terms of ASA. On some types of roll film (ex. 120 roll film), the manufacturer may omit the data sheet and publish the exposure information on the film wrapping.

The photographic film emulsion is made up of a combination of silver halides and gelatin. These silver halide grains are of varying sensitivity. Some of the grains are highly sensitive, while others are less sensitive to light. In a high-speed film, the emulsion coating contains a larger proportion of the most sensitive grains. In a low-speed film, the larger proportion of silver halide grains would be those of less sensitivity. If a given area on a piece of film is exposed to light for a very short time, only the more sensitive grains are exposed, and the area is pale gray after development. If this is a fast film, it includes more of the sensitive grains, and the result is a darker shade of gray after development. Therefore, with a given amount of light and the same development, the faster film always produces a darker shade of gray (greater density) than the slower film, since a greater percentage of silver halides have been exposed and developed.

The practical application of a film-speed number is rather simple. Let us assume that you have been using a particular film for a considerable length of time. Through your experience in taking photographs with this film, you have found that when photographing a brilliant subject under daylight lighting conditions, the correct exposure has been 1/125 of a second at f/16. This film has been rated at a speed of 125. Now suppose under the same circumstances you are using a film with a speed of 250. What does this mean to you? It simply means that the new film is twice as sensitive to light as the old one. To compensate for this increased sensitivity, you could adjust either or both the camera's shutter speed or diaphragm to make the necessary correction. The new exposure for this film could be 1/125 at f/22, 1/250 at f/16, or 1/500 at f/11.

The recommended film speed published by the manufacturer is usually computed for average conditions. You should, however, adjust the number according to your particular working methods and equipment. This is particularly true when you consistently get overexposed or underexposed negatives.

You should choose your mission film with its speed in mind. Generally speaking, you should choose the slowest speed film that will accomplish the mission objective. The slower speed film gives you comparatively better grain and resolving power (sharpness). Range of f/stops and shutter speeds (i.e., exposure) available under the scene's lighting conditions also dictates your film speed choice. For example, a portrait is normally shot with a wide aperture to reduce depth of field (area of sharpness). Choosing a fast film for an outdoor portrait on a sunny day would limit you to fast shutter speeds and small apertures. Conversely, under low light conditions where wide exposure latitude is needed, or on an airborne mission where fast shutter speeds are desired, a high-speed film is ideal.

Exercises (204):

1. Identify the organization that establishes procedures for determining film speed.

2. Complete the following statements in regard to film speed.
   a. Knowing your film speed number is essential in calculating your photographic__________.

b. A film with an ASA of 400 is twice as sensitive to light as one having a rating of ____________.

c. Given the same exposure and development, the faster speed film produces the greater____________.

d. As a general rule, you should choose the ____________ speed film that will accomplish the mission.

e. In sunny conditions, a ____________ speed film gives you a wider choice of apertures and shutter speeds.

1-5. Contrast

A major factor in selecting a film is the inherent contrast of the emulsion. Together with development and subject lighting, inherent or built-in film contrast is one of the most important contrast determining factors. Photographic emulsions, in varying degrees of contrast-producing capability from very low to very high, are available. Your choice of emulsion is influenced by the nature of the subject and by whether it is considered desirable to decrease, maintain, or enhance contrast. It is, therefore, important to choose your film with its inherent contrast in mind.

205. Define film contrast and state selected factors and characteristics related to it.

Density can be referred to as the amount of metallic silver that has been exposed and processed in any area of the emulsion. The difference between the high and low densities of the various areas of the emulsion is called *contrast*. A bright area of the subject reflects a great amount of light, causing a correspondingly heavy density in the negative, called a highlight. A dark area reflects little light, resulting in a correspondingly thin density, called a shadow, in the negative.

The subject brightness between these light and dark areas also registers as various densities of middle tones. The difference in brightness, from the highlights to the shadows, is called contrast. Normal contrast is represented by a full range of densities, including highlights, middle tones, and shadows. High contrast does not have a full range of densities and consists primarily of highlights and shadows with little or no middle tones. Low contrast has very little density differences.

Emulsions are manufactured with varying degrees of inherent contrast. High contrast (process) film is used to record high contrast black-and-white subjects, as when copying line drawings. Medium and low-contrast films are used to record a longer range of tones such as might be found in a portrait. Therefore, the selection of the film should be governed by the contrast of the subject and the rendition desired.

The inherent contrast of an emulsion is the possible difference between the maximum and minimum densities of the silver deposit formed with a minimum variation in exposure intensities. Usually, the emulsions which have the slowest speed have the highest inherent contrast. The reason for this is that the slow film has smaller and more uniform silver halide crystals which respond more slowly to light of low intensities in relation to light of high intensities. The fast films have larger crystals due to the ripening during manufacture. These films respond to lower intensities of light much more rapidly in relation to the higher intensities than the slower films. This tends to flatten out or lower the contrast of faster films.

Contrast of the final result can be influenced by many other factors. Development has a definite effect. In general, the greater the development the greater the contrast. The lighting conditions of the original scene and the reflectance values of the subject determine the contrast of the scene you are shooting. Therefore, it is very important to match the film and developer combination to the scene in terms of the final result that you want to achieve on your negatives.

Exercises (205):

1. Define contrast in terms of density.

2. In terms of density, state what is a normal contrast negative.

3. Identify what speed of film would have the higher inherent contrast.

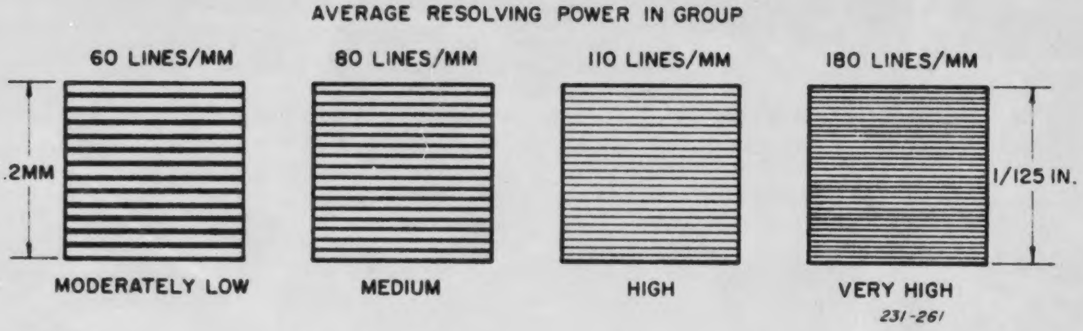

Figure 1-4. Examples of line resolution for typical emulsions.

4. State the effect that development has on contrast.

1-6. Resolving Power

The term resolving power is used to describe the inherent property of an emulsion to resolve (reproduce) fine detail in the image. Resolving power is often expressed as the number of lines-per-millimeter (a millimeter is approximately 1/25 of an inch) that can be individually distinguished in the photographic image. Hence, the smaller the distance between the individual lines, the higher the resolving power. Or, the more lines per millimeter, the greater the resolving power as shown in figure 1-4.

206. Complete statements about resolving power.

Resolving power can be compared with several other characteristics of any film, as shown in figure 1-5. It is affected by so many factors that no one factor can be stated as the determining one except when particular conditions are stated. As with grain, to make high-quality enlargements from your negatives, you should select a film with high resolving power.

Effect of Exposure. The effect of exposure on resolution is significant. Resolution declines appreciably with overexposure or underexposure. Emulsions designed specifically to produce maximum resolving power may have an optimum density quite different from the optimum density for normal films. Therefore, even though a film is capable of resolving a large number of lines per millimeter, this is not necessarily an indication of what image quality the film will produce under actual, normal operating conditions where subject contrast, processing, and exposure cannot always be at the optimum level for maximum resolution.

The resolution capacity of films is constantly being improved. Usually, the very high resolution materials have extremely slow speed and very high contrast, which, as you recall, is characteristic of all the ultrafine grain emulsions. Fine grain is one of the prime

FILM CHARACTERISTICS

Film Speed	Apparent Grain	Resolving Power	Latitude	Contrast
Fast	Coarse	Below 50 lines per millimeter	Wide	Low
Medium	Medium	50 to 75 lines per millimeter	Medium	Medium
Slow	Fine	Above 75 lines per millimeter	Short	High

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Figure 1-5. Film characteristics.

factors in high resolution emulsions. Another important factor is correct processing. As you can understand, the choice of a particular film for a mission involves compromises between speed, grain, contrast, latitude, and resolving power.

Exercise (206):

1. Complete the following statements concerning resolving power.
   a. Resolving power is affected by __________ photographic factor(s).
   b. Over or under __________ will cause resolution to decline.
   c. Normally, film having very slow __________ and __________ contrast has the best resolving power.

1-7. Storage and Preservation

Both the emulsion and the base of film are designed to be stored and used under specified conditions and within certain tolerances. Because of this, proper handling and storage conditions must be maintained if you expect good photographic results. If you use a film that was stored in a cabinet next to a heater, chances are good that the emulsion is fogged. Using fogged film does not enhance image quality. Not only is your photograph unusable, but the entire supply of film is also ruined. The result is costly to the Government. The loss of valuable and sometimes irreplaceable information on the negative cannot be condoned. Let's discuss the effect of temperature in more detail and also consider other problems arising from poor storage and use of film.

207. Complete statements regarding film storage.

Effects of Low Temperature. At low temperature, film becomes somewhat brittle and stiff, and emulsion cracks occur. This is especially true when film must be rolled from a 35mm cartridge and rerolled on a takeup spool. Normal moisture content in the film helps reduce problems. With care, film used at temperatures as low as minus 60° F has produced acceptable results. Shrinkage and excessive curl may cause some problems, depending on the particular equipment used. Cold also increases the danger of abrasions and static electricity markings.

If you have taken high school chemistry, you may remember that cold slows down chemical processes. The reaction of film to the exposing (and developing) process is no exception. Film speed is reduced by cold. As an example, at one time the Air Force conducted tests that showed that a film with a speed of 100 at normal temperatures dropped to a speed of 12 at minus 50° F. A drop in film speed due to low temperature is best determined for a specific emulsion by trial and error as the occasion arises.

Effects of High Temperature. The primary consideration in protection of film from high temperature is proper care—not during immediate use, but rather while it is in storage. For short periods, normal room or outdoor temperatures are generally satisfactory. However, for extended storage periods, lower temperatures are advised. Storage at 65° F is adequate for conventional materials when there is a reasonably rapid turnover of stock. A moderately high temperature for a short time is not particularly destructive to film, but extended storage at high temperature does cause an overall fog. A factor in short or long storage periods, equally or more important than temperature, is humidity coupled with temperature changes.

We have mentioned previously that film speed drops at lower temperatures. The opposite is usually true as temperature rises. You should note that temperature (and humidity) changes do not affect all film emulsions in the same manner or to the same degree. Also, any speed (density) or contrast increase is effective only to a certain temperature and time duration. As temperature, time, or both, pass a certain point, the increase in density and contrast are masked by an increase in fog.

Storage conditions to be avoided for even short periods of time include hot, unventilated storage rooms or lockers, automobile glove compartments or trunks, and any other abnormally hot areas. Direct rays of the sun or high intensity lamps must also be avoided. It is only too easy to lay a film holder on top of a camera case, window ledge, or similar surface exposed to direct sunlight. Since the holders are black, they rapidly reach extreme temperature.

Humidity. The moisture content of the air is very closely related to temperature. If humidity and temperature are both improper, even a short storage period can cause pronounced image degradation. High temperature and excessive humidity in combination is common and may cause fog, provide an opportunity for growing fungus, produce transparent spots, etc. Excessive humidity plus temperature fluctuation cause condensation of moisture. If moisture condenses on film, it causes many complications.

It is usually recommended that film be used and stored at never more than 60-percent relative humidity. On the other hand, a very low humidity and low temperature causes film to become dry and brittle and curl up. Most film is packaged by the manufacturer at 50-percent relative humidity. In general, humidity during storage is not a problem as long as the package seal is unbroken.

We have mentioned that film should be stored at low temperature and at about 50-percent relative humidity. But, before using it, you must allow the film to come to room temperature in its unopened package. This allows the film and its wrapping to come into equilibrium with the surrounding atmosphere and temperature of the room. This precaution prevents moisture condensation on the film.

Static Electricity. When one material, either positively or negatively charged, comes close to or contacts another material having an opposite charge, there is an electron transfer—a spark. This is static electricity, and it is especially bad under low humidity conditions. You may have, at times, shuffled across a carpet, then reached for a doorknob and shot a spark from your fingertips to the metal. Such a spark close to a sheet of undeveloped film can expose the film. The exposure looks much like the image of a streak of lightning.

Static electricity is caused by friction or by contact and rapid separation of materials. The best protection against it is to handle the film properly under conditions that minimize static electricity generation. All equipment should be grounded and any film movements (removal from holders, respooling, etc.) should be slowed down to minimize static generation. Additionally, if your laboratory area is quite dry, it may be desirable to humidify the air to about 40- or 50-percent relative humidity to reduce generation of static electricity. Fifty-percent humidity is desirable, even if static electricity has not been a problem.

Latent Image Keeping. Certain problems arise concerning the length of time that the latent image can be retained. It is often impractical to develop a piece of film immediately after exposure. Therefore, the latent image must be retained for at least a reasonable time. A sheet of film after exposure still contains the silver halides that were not used during production of the latent image. Thus, the film must be protected against any further action of light before development and fixation.

Storage in a holder or cartridge is usually adequate if the container is light tight; however, do not store under bright light which may eventually produce fog. Even if the container is light tight, bright sources of light generate harmful heat.

Earlier, we mentioned humidity during storage of unexposed film. It is equally important here. Generally, the ideal storage of exposed film is the same as for storage of unexposed film. As a guide, tests have shown that a latent image can safely withstand a temperature of 75° F. and a relative humidity of 60 percent for about 3 days before any effect is noticeable.

Abrasions. Markings are caused by film rubbing against another surface. The minute markings can eventually accumulate to the point where a negative is of no value. To see the effect of abrasions, look at slides or motion pictures that have been projected many times. The obvious prevention is to avoid subjecting film to needless handling and friction, whether the film is processed or unprocessed. Also, since dust particles are abrasive, keep the film and surroundings as clean as possible. Exposed film unloaded from holders and laid on a dusty table provides a quick and easy method of generating abrasions, especially if you slide the film while it is in contact with the table.

Glass Plates. Many specialized areas of photography use emulsions coated on glass plates. Plates are used when an exceptionally stable support is needed, such as in the fields of astronomy, missile tracking, and map construction. Glass plates are optically flat and quite stable during thermal changes. Humidity has little effect, except to swell or contract the emulsion in a vertical direction.

Because of their physical properties, glass plates are difficult to store and handle. The problem of breakage is always present. Also, because of their bulk, they must be conditioned to their surroundings for a greater length of time before use. A single plate can be tray-processed, but a special cage must be used to hold the plates during tank processing.

Exercise (207):

1. Complete the following statements related to the storage of film.
   a. At low temperature a film's emulsion may_______________.
   b. In the cold, film speed is__________________.
   c. Continuously storing film at high temperatures may cause____________.
   d. Film should not be stored in conditions that exceed ___________ humidity.
   e. Prior to using film that has been stored, you should allow it to come ____________ to room temperature.
   f. Static electricity is more likely under conditions of_____________humidity.
   g. A latent image should be protected from _____________that could cause fog.
   h. Friction from improper handling of film can cause____________________.
   i. Glass plates must be carefully handled because they are subject to______________.

1-8. Orthochromatic Film

Eventually, dyes were added to blue-sensitive emulsions to make the silver halides sensitive to green light as well as to blue light. This film was named orthochromatic (true color) because it was felt that the ultimate in color sensitivity had been reached. The term was incorrectly applied, however, since the emulsion is not sensitive to red and, therefore, does not reproduce red in its correct shade of gray.

208. State the color sensitivity of orthochromatic film and explain why this limits its use.

Ortho films, as they are often called, are made in several speeds and variations in the amount of their color sensitivity. They are excellent for many uses, provided that their incorrect rendition of the color red is taken into consideration when the scene is being photographed. Since they are not sensitive to the color red, red light does not (for practical purposes) make a latent image on the film. Therefore, after processing, red objects are relatively transparent on the negative and darker than normal on the print. As an example, ortho film is good for a portrait of a man. But, you would not use it to photograph a woman who is wearing makeup. If you did, the light reflected from her red lipstick would not expose the film and her lips would look much too dark (almost black) on the print. Presently the Air Force orthochromatic film is mainly used in copy work.

Exercise (208):

1. State the color sensitivity of orthochromatic film and explain why this limits its use.

1-9. Panchromatic Film

After dyes which could sensitize an emulsion to the green wavelengths of light (orthochromatic) were developed, researchers developed dyes which could sensitize silver halides to even longer wavelengths. This enabled the manufacturers to produce panchromatic emulsions that were sensitive to blue, green, and red light. Film sensitivity was extended to light which had wavelengths near 700 nanometers. The first panchromatic film came closer to approximating the sensitivity of the human eye than either the blue sensitive or orthochromatic emulsions.

209. Given a list of photographic characteristics, identify those that apply to panchromatic film.

Through further research, two additional and distinctly different types of panchromatic emulsions were made. Panchromatic emulsions are classified as types A, B, and C. The original panchromatic emulsion, type A, has limited green sensitivity, and for this reason is not very popular today. Most of the current panchromatic emulsions are types B and C. Type C has considerably greater red sensitivity than type B. The sensitivity of type B film closely compares with the sensitivity of the eye.

Why is a panchromatic film desirable? Several factors are involved. For one thing, the red sensitivity of the emulsion tends to make the emulsion more sensitive to light and, therefore, promotes increased emulsion speeds. Red sensitivity is also important in trying to achieve orthochromatic rendition. (Orthochromatic rendition is rendering the scene in terms of gray tones in the same manner as the eye sees the scene.) Many panchromatic emulsions have the capability of recording fine detail and of producing good contrast. For these reasons, panchromatic film has become the standard black-and-white film for almost all missions.

Exercise (209):

1. From the following list, identify which characteristics apply to panchromatic film.
   a. Sensitive only to blue light.
   b. Poor tonal separation.
   c. Sensitive to red light.
   d. May be used to achieve orthochromatic rendition.
   e. Type A film is very sensitive to green light.
   f. Type C film is very sensitive to red light.

1-10. Polaroid

Photographers sometimes use Polaroid film to produce photographs when there is insufficient time for conventional processing methods, as in police work. As a training aid, Polaroid film provides a means for learning many photographic principles without the delay required for normal film processing and printing. Polaroid, which can produce a positive image within a matter of seconds, is also ideal for checking lighting or composition prior to using conventional film.

210. Identify the characteristics of different types of Polaroid films with their appropriate identifying numbers.

The Polaroid system is a specialized silver halide process. The outstanding feature of this system is that a finished print is available to the photographer in a matter of seconds after exposure, since the entire process can be carried out in the camera (or outside in some later models.) The positive image is developed by diffusion transfer which causes the latent image to be physically developed in a chemistry containing a silver halide solvent (hypo). In the Polaroid system, the exposed negative is developed in a high viscosity monobath solution. This solution is sandwiched between the exposed negative and the non-light sensitive positive transfer sheet. After a suitable developing time has elapsed, the two sheets are separated, and the positive image is contained in the transfer sheet.

Polaroid makes available a variety of film for different purposes including copy work and infrared recording. The following is a description of the more common types you may be using.

Types 42 and 52. Both of these films have medium speed, good tonal ranges, fine grain and medium contrast. Type 42 is a roll film producing a 3½" x 4½" image size with an ASA speed of 200. Type 52 comes in single exposure packets producing a 4" x 5" image size with an ASA of 400. Development time for both films is 15 seconds at 75° F.

Types 105 and 55 P/N. Type 105 is a 3¼" x 4¼" eight-sheet pack film with an ASA of 75. It produces medium contrast fine grain prints and a usable negative that can be used for normal print production. 55 P/N has the same capability but in single 4" x 5" exposure packets with an ASA of 50.

Types 47, 57, and 107. Type 47 is a roll film with an image area of 3¼" x 4½". Type 57 is a 4" x 5" single exposure packet film. Type 107 comes in 3¼" x 4¼" film packs. All three of these panchromatic film types have an ASA of 3000 which makes them ideal for photography of high-speed events, many scientific applications, and general photography. As with conventional materials having high speed, resolution on the paper positive is low compared to slower films.

Exercise (210):

1. Match the Polaroid film types listed in column A with the appropriate description listed in column B.

Column A

1. Type 42.
2. Type 52.
3. Type 105.
4. Type 47.
5. Type 57.
6. Type 107.

Column B

a. ASA 3000 pack film.
b. Film has an ASA of 50 and produces both a positive and useful negative.
c. Roll film with an ASA of 200.
d. Roll film with an ASA of 3000.
e. Pack film that produces a negative and a positive.
f. Single exposure pack film with an ASA of 3000.
g. Pack film with an ASA of 400.
h. Single exposure packet film with an ASA of 400.

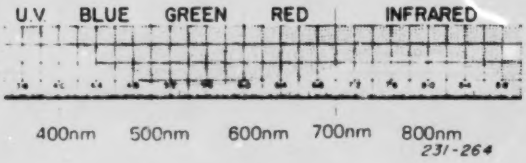


Figure 1-6. Sensitivity of infrared emulsion.

44

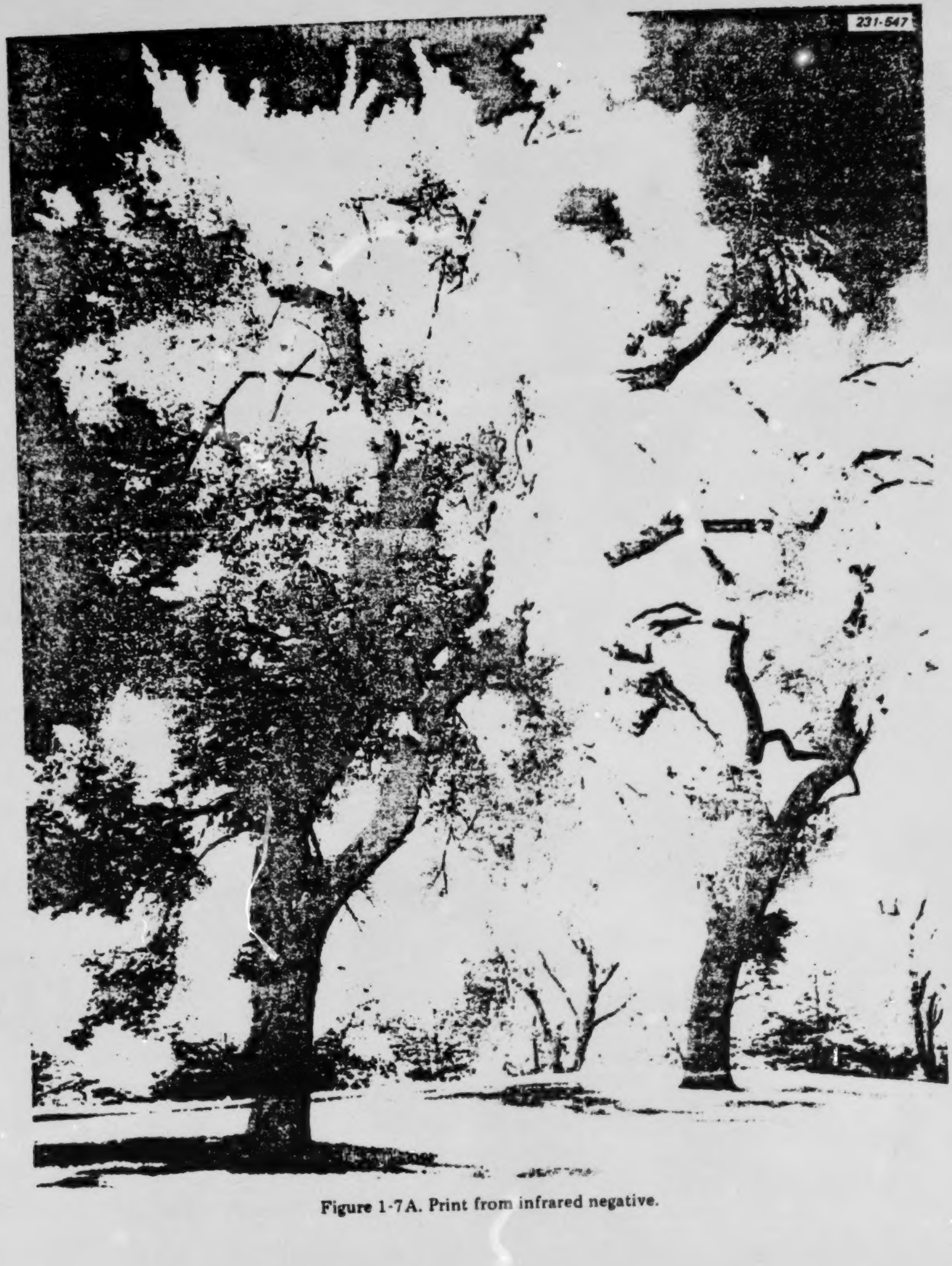


Figure 1-7A. Print from infrared negative.

45

1-11. Infrared Film

Infrared film is sensitive to the infrared (generally in the region of 700 to 900 nanometers in wavelength) portion of the electromagnetic spectrum which we consider as being invisible radiation. Even though infrared is not visible to the human eye, this film can "see" it; consequently, an exposure can be made.

211. Complete statements about the characteristics of infrared film and procedures for its use.

In addition to the infrared sensitivity, the film is also sensitive to some ultraviolet and visible blue light. Because of the blue sensitivity, a filter must be used over the lens to absorb the blue light in order to obtain the proper infrared effect. Generally speaking, any deep red filter can be used; however, it is advisable to follow the manufacturer's recommendations. Figure 1-6 shows the sensitivity of infrared emulsions.

Infrared film has many applications in conventional, as well as aerial and scientific photography. In situations where sharp definition and contrast differentiation for distant objects are required, infrared film has definite advantages. The use of a panchromatic film in combination with a red filter provides good haze penetration where distant objects would otherwise be obscured. Although this haze penetration is good, the use of infrared film gives even greater haze penetration.

Since the infrared radiation has long wavelengths, it will not focus in the same plane as visible light. Because of this, it is necessary to refocus the lens. The lens-to-film distance must be slightly increased. Many newer cameras are equipped with an index mark to show the infrared focus point. If this point is not marked, it is advisable to use a small diaphragm opening to obtain as much depth of focus as possible.

One of the features of an exposure taken outdoors on infrared film is the peculiar effect in the areas of natural vegetation. Normally, it would seem as though green subjects would produce very little exposure. This is true where the objects are colored green. Natural foliage that contains chlorophyl, however, causes a heavy exposure. The foliage, therefore, appears very white on a print. Infrared photography is used extensively by conservationists to identify diseased trees and plants. Compare the difference between figure 1-7A, a print made from an infrared negative, and figure 1-7B, which was made from a panchromatic negative.

Crime labs use infrared photography to detect forgeries and erasures, to decipher charred documents, and to distinguish between various dyes, etc. In addition, infrared film is useful in medical photography and other scientific and technical applications where infrared radiations are to be recorded.

Exercise (211):

1. Complete the following statements related to the characteristics of infrared film.
   a. When using infrared film, a ______ filter should be used.
   b. Infrared film gives better ______ penetration than panchromatic film.
   c. To insure proper focusing, the lens-to-film distance must be ______ when using infrared film.
   d. Natural living foliage will produce a ______ exposure on infrared film.

52

46

231-547

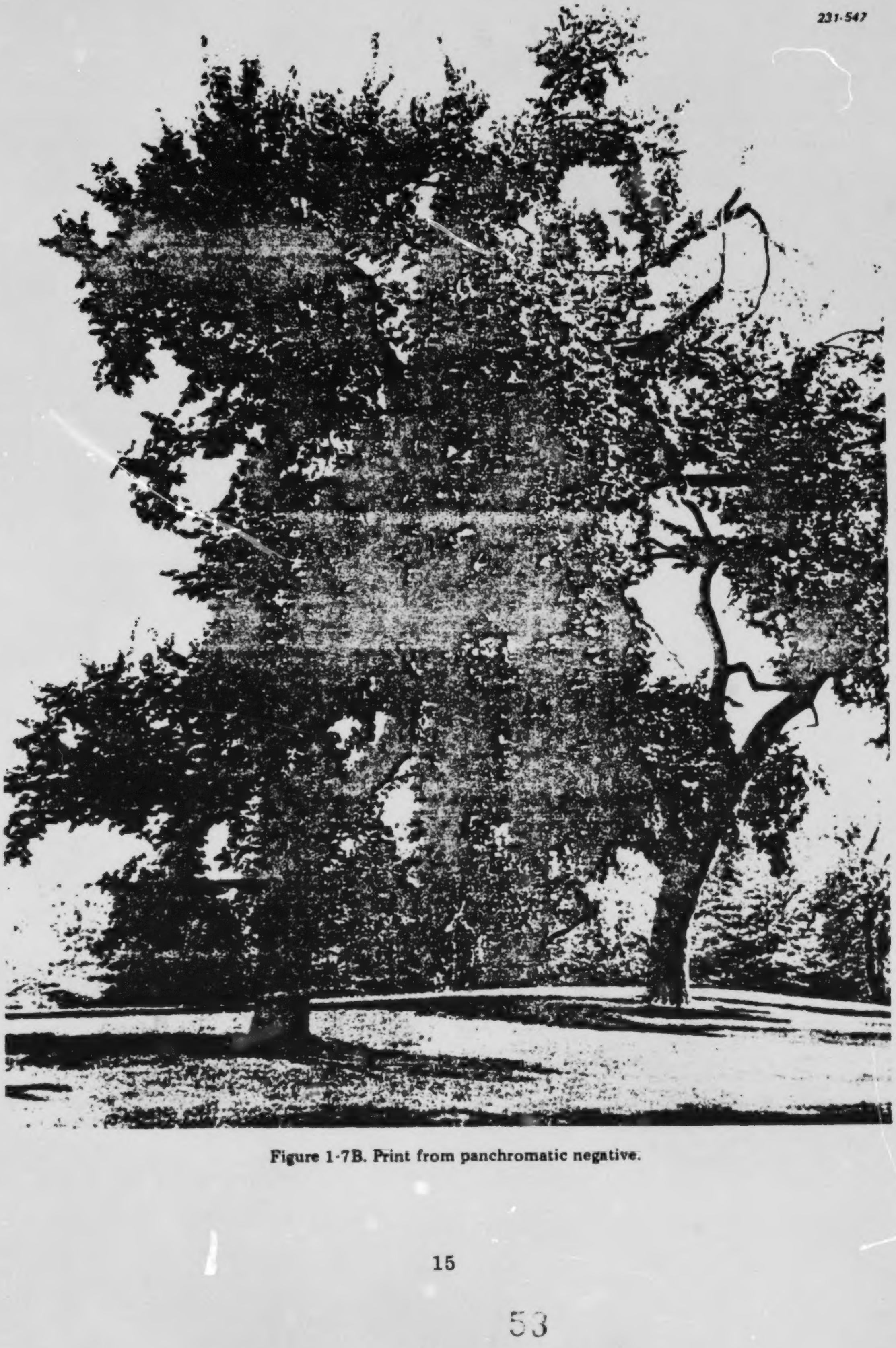


Figure 1-7B. Print from panchromatic negative.

CHAPTER 2

Photographic Exposure

A PROPERLY EXPOSED negative is the starting point of the photographic process. If you don't expose for it, there will be no image on the negative. Therefore, in this chapter we discuss basic exposure theory, the scene brightness range, reciprocity effects, the problem of haze, and the use of data guide charts, meters, and gray cards. The continued study of these various elements will help you gain confidence in this most important photographic step.

2-1. Exposure Factors

A photographic exposure is the controlled application of image forming light to a light-sensitive material. This exposure puts the photographic process in motion to produce the desired end product. You must correctly expose the material if you want to form an image having proper density and adequate detail.

212. State the basic exposure formula and describe each exposure factor.

The term "exposure" means the amount of light which is permitted to act upon a photographic emulsion. A light of high intensity may be permitted to act for a short time, or one of lesser intensity for a greater time; yet both exposures produce the same photographic effect on film. The exposure formula, which applies to most practical work is: Exposure = Intensity × Time. Intensity, in this case, refers to the brightness of the light striking the film and depends on the lens setting (aperture) in conjunction with the light reflected from the subject. Time is the interval during which the shutter permits the light to reach the film.

NOTE: Aperture settings and shutter speed selection are functions of camera operation which will be explained in greater detail in subsequent sections. For the time being, consider the aperture as a "hole" inside the lens that permits image forming light to pass to the film. The size of the aperture can be controlled by a diaphragm and the size is indicated by an f/stop (ex. f/8). The shutter is a mechanical or electronic device which acts as a curtain in front of the diaphragm or in front of the film. In either case, it controls the amount of time that light is permitted to strike the film.

Let's demonstrate the exposure formula by exposing three sheets of film of the same scene. For example, expose the first at 1/125 second at f/11, another sheet at 1/60 at f/16, and a third at 1/250 at f/8. Develop all three sheets exactly alike. All the negatives will have the same density since they have all had the same amount of exposure. In this demonstration, the exposure has remained constant while both *intensity* and *time* have been varied. For example, when the intensity was reduced by one half by going from f/11 to f/16, then the time was doubled by going from 1/125 to 1/60 to keep the total exposure equivalent.

If three exposures, however, are made with the intensity remaining constant at f/11 while the time is varied by 1/125, 1/60, and 1/30 of a second, the negatives vary considerably in density. In these cases the exposure does not remain constant, since 1/60 allows two times and 1/30 four times as much exposure as 1/125. The same principle applies if the shutter speed remained at 1/125 and the lens aperture was changed each time from f/11 to f/16, and then f/8. The negatives again would vary in density because f/16 would allow in half as much and f/8 would would double the amount of light as compared to f/11.

Exercises (212):

1. State the formula for determining exposure.

2. Describe each factor and give its camera control.

213. Define film speed, state the interrelationship of apertures and shutter speeds, and select equivalent exposures from various combinations of shutter speeds and apertures.

Film Speed. Film has been mentioned several times in our discussion of factors governing exposures. Chapter 1 of this volume explained the sensitivity of various types of films to various wavelengths of light and general degrees of sensitivity and speed rating of negative materials in order to calculate the correct exposure required to produce a given density on the film.

The major American, European, and Japanese manufacturers have adopted a single, unified system of rating film speeds known as the American Standards Association (ASA) system. (The present name of the certifying organization is the American National Standards Institute (ANSI). However, since film manufacturers are still using the ASA identifier for film speed, we will do the same in our discussion.)

With this method of calculating film speed, a speed number is assigned, and its rating has the same value as far as exposure is concerned regardless of who manufactures the film. The film speed is indicated by a numerical rating (64, 125, 400, etc), which has been determined through testing. A film with a speed rating of 250 is twice as fast (sensitive to light) as one with a rating of 125; that is, it requires only half as much exposure to produce the same amount of density, all other factors remaining the same.

The speed number indicated on each package of film is intended to be used with exposure meters, or any other aid in calculating exposure. This speed number greatly simplifies your problem when changing from one brand of film to another.

Equivalent Exposure. The combination of the shutter speed and the aperture setting determines the amount of light that is exposing the film. While there are certain circumstances that limit the choice of aperture shutter combinations, under most conditions there are many shutter speed aperture settings that will produce equal amounts of exposure. Settings that give equal amounts of exposure are called equivalent exposure settings. Remember that a correct exposure results from a combination of shutter speed and aperture settings. Now, let's see how each one of these factors functions to control the action of light.

Shutters. Most shutters have a range of instantaneous speed settings, in addition to settings for time (T) and bulb (B). The time setting is used for extremely long exposures, sometimes hours in duration. The shutter is tripped to begin the exposure and then rotated to close the shutter when the desired exposure interval has lapsed. The bulb setting is usually used for times that are slightly longer than the instantaneous settings (i.e., 2 seconds to several minutes). The shutter remains open only as long as the shutter release is depressed—usually with the aid of a cable release. Releasing the release closes the shutter.

The instantaneous settings generally mean exposures lasting for a fraction of a second. These shutter speeds normally range from 1 second to 1/1,000 of a second or less. For example, setting the shutter speed indicator at 60 means that the shutter will be open for 1/60 of a second after the shutter release has been tripped. The number 4 means that the shutter would be open for 1/4 of a second, etc.

Each shutter speed is increased (approximately) by a factor of 2. This means that the next fastest shutter speed reduces the exposure time by one-half and the next slowest shutter speed doubles the exposure time. For example, moving from a shutter speed of 1/60 of a second to 1/125 of a second reduces the exposure time by one-half, but going from a shutter speed of 1/125 to 1/60 second doubles the exposure time.

Apertures or F/Stops. Intensity is controlled by a series of interlocking leaves (iris diaphragm) which are adjustable so that you may increase or decrease the opening through which light passes to strike the film. The f/stops are numbers marked on the diaphragm ring to indicate the various apertures. When the aperture diaphragm is moved to the smallest number (f/1.4, for example) the iris diaphragm is wide open and admits the maximum amount of light. As the numbers increase (2, 2.8, 4, etc) the size of the aperture becomes smaller, reducing the amount of light entering the camera.

Lens manufacturers have standardized f/stop scales starting with f/1 and progressing by the square root of 2 through the various full f/stops. An important advantage of this system is that each higher numbered f/stop reduces the intensity of the light striking the film by one-half. The term *full f/stop* is applied to the following f/stops: f/1, f/1.4, f/2, f/2.8, f/4, f/5.6, f/8, f/11, f/16, f/22, and f/32. The term *lens speed* refers to the largest aperture (i.e., the smallest f/number) of the lens.

The phrase "closing down a stop" means moving from one full f/stop to the next larger *number*, such as from f/11 to f/16. Doing this reduces the light intensity by one-half. Opening up one stop produces the opposite result. In this case, as you move from a larger number to the next smaller number (f/16 to f/11), the light intensity doubles.

Since both aperture and shutter speed settings can control exposure, it is possible to alter exposure by changing either the aperture or the shutter speed setting. As an example, if you want to double the amount of exposure for a certain film, you can open up the lens one f/stop or you can double the exposure time by moving to the next smaller number.

The term "close down one stop" is also a short-hand way of saying, "*Reduce your exposure by one-half.*" This reduction can be accomplished by doubling your shutter speed or using the next smaller lens aperture. Sometimes it may be to your advantage to change one rather than the other. For example, let's assume that you are photographing a subject that requires a certain depth of field. In this case you would adjust the shutter to provide the necessary exposure, as depth of field is controlled in part by the aperture closing. The choice, of course, is up to you and is part of your control over the quality of the final photographic product.

Exercises (213):

1. Define film speed.

2. State how a combination of aperture setting and shutter speed controls exposure.

3. Solve the following problems by selecting the correct equivalent exposure.

a. 1/60 at f/8 is equal to: 1/25 at f/11
1/30 at f/16
1/250 at f/4

b. 1/250 at f/5.6 is equal to: 1/125 at f/2.8
1/500 at f/8
1/60 at f/11

c. 1/30 at f/11 is equal to: 1/125 at f/8
1/60 at f/16
1/250 at f/4

214. Define scene brightness range and briefly explain why the scene brightness range affects the information that is recorded on the film.

Scene Brightness Range. When you view a typical scene, your eyes respond to the color of light reflected by each part of the subject. Your camera lens focuses this light upon the film and forms an image in natural color. However, black-and-white photographic films can only reproduce these colors in various shades of gray. The density of these various shades depends on the brightness of the reflectance of each subject color and the color sensitivity of the film. The relative difference between the brightest areas (highlights) and the darkest areas (shadows) is termed the scene brightness range (SBR).

Typical photographic scenes may have scene brightness ranges from 1:2 to well over 1:500. This is to say that, by comparison, a shadow is 1/2 to 1/500 as bright as the highlight in the scene. Common film emulsions are capable of recording all of the extremely low scene brightness ranges, but few can record very high ratios of shadow to highlight brightness. The problem is compounded by typical printing paper emulsions which can only record tone differences of 1:30 or less.

Most films are properly exposed when the brightest highlight creates the greatest practical image density. This practical maximum occurs when 128 times the minimum amount of light strikes the average black-and-white film. At this point, we can say that the range of the particular film is 1-to-128. Any object reflecting more than 128 times the minimum amount of light will end up as a washed-out highlight.

When an original scene contains a greater brightness range than the film can capture (for instance, a scene brightness range of 1 to 600), you can photograph any slice of the scene that contains a 1-to-128 ratio of light units. You can photograph 2 to 256 light units or 4 to 512 units; any ratio that reduces to 1 to 128. Remember that any areas that reflect less light than our low point will result in a clear negative, and areas above our high point, will result in a "blocked up" area of the negative.

Exercises (214):

1. Define scene brightness range.

2. Briefly explain why the scene brightness range affects what information will be recorded on the film.

215. Briefly explain the law of reciprocity, the conditions under which there is likely to be a failure of reciprocity, and the effect of reciprocity failure.

Reciprocity Law. Earlier, we defined exposure as the product of the *intensity* of the light reaching the sensitized material and the *time* of exposure: $E = I \times T$. The amount of photographic chemical reaction or silver image density is dependent upon the exposure received by the film or paper. This equation is also known as the *reciprocity law.*

Applying the law of reciprocity, if no other factors were involved, you should expect the same density to be produced on two samples of sensitized materials having the same speed (assuming equal development), even though one sheet of the material is exposed to 500 units of light for 1 second and the other to 1 unit of light for 500 seconds. The product of the light intensity and the time of the light action is the same for each exposure.

Let's take another example. An exposure of 1/250 second at f/8 is equal to an exposure of 1/60 at f/16. In a practical sense, the reciprocity law holds true for the normal range for exposure time. The normal range for various sensitized materials differs considerably. Many films have a normal range of 1 second to 1/500 second; others have a normal exposure range of between 1/10 and 1/1,000 second. Failure of the reciprocity law to apply in this normal range is insignificant, and you can disregard it for most practical applications of photography. This is why published tables, exposure calculators, and exposure meters can be used in most of your day-to-day photography.

Unfortunately, photographic emulsions do not always respond in such a manner that constant results are obtained when light intensity and exposure times are widely varied. What we are saying is that the reciprocal relationship of intensity and time as outlined in the exposure equation does not hold true in some applications. Instead, film is less responsive when it is exposed under extremely high or low light intensities as compared to exposure under medium intensities. Both extremes are usually marked by very short or very long shutter speed settings.

It is interesting to note that at both extremes the effect of reciprocity failure is an apparent loss of film speed. The loss of film speed results in an underexposed negative. The extent of speed loss differs with different emulsions under varying conditions and no general rule can be given. Required exposure compensation for reciprocity failure must be found by experimentation for each emulsion. The best insurance against reciprocity failure is the use of the aperture, rather than extremes of shutter speeds, to control exposure.

Exercises (215):

1. Briefly explain the law of reciprocity.

2. Explain under what conditions there is likely to be reciprocity failure.

3. Explain the effect of reciprocity failure.

216. Identify, as true or false, statements concerning haze and its effect on photographic exposures.

Haze. The term "atmospheric haze" is used in photography to describe a condition of the air. This condition, haze, may take the form of a thin vapor of fumes, smoke, or dust. Haze effects are sometimes used to heighten the dramatic impact in photographs, but on other occasions haze may present a serious problem as it obscures vital details.

Haze acts as a filter and scatters the shorter (blue) wavelengths of light. Haze, therefore, effectively softens details. Such softening can give a feeling of depth or mood to pictorial shots. Conversely, there may be occasions when you wish to eliminate or reduce the effects of atmospheric conditions to achieve maximum detail. These include but are by no means limited to:

- Aerial reconnaissance.
- Aerial mapping.
- Aerial surveys.
- Telephoto photography for sports or nature.
- Missile launchings.
- Astronomical photography.

To minimize or eliminate haze to show distant subjects in greater detail, panchromatic or infrared emulsions must be used. These films are selected because they are sensitive to red or infrared wavelengths. These longer wavelengths are not as affected by haze.

The use of panchromatic film and a yellow filter can improve clarity to some degree. Even greater detail may be obtained by using dark yellow or orange filters. To penetrate heavy haze you should use a red filter. Maximum penetration can be achieved by using infrared film and a dark red filter. It must be emphasized that these methods apply to haze penetration. Ordinary film and filter combinations do not penetrate fog or some other types of atmospheric conditions.

NOTE: Yellow, orange, and red filters are used to absorb blue wavelengths of light which predominate in hazy conditions. The correct use of filters will be discussed in detail in a later chapter.

Exercise (216):

1. Identify each of the following statements as true or false.
   a. Haze obscures detail in a photograph.

DAYLIGHT EXPOSURE TABLE 231-294

USE SHUTTER SPEED WHICH IS RECIPROCAL OF FILM SPEED

BRIGHT SUN ON LIGHT SAND OR SNOW	BRIGHT SUN SUBJECT IN DIRECT SUNLIGHT*	HAZY SUN SOFT SHADOWS	CLOUDY BRIGHT WITH NO SHADOWS	OPEN SHADE WITH CLEAR BLUE SKY	DEEP SHADE
BRILLIANT SUBJECT f/32	BETWEEN f/22 – f/32	f/22	f/16	f/11	f/8
BRIGHT SUBJECT f/22	BETWEEN f/16 – f/22	f/16	f/11	f/8	f/5.6
AVERAGE SUBJECT f/16	BETWEEN f/11 – f/16	f/11	f/8	f/5.6	f/4
DARK SUBJECT f/11	BETWEEN f/8 – f/11	f/8	f/5.6	f/4	f/2.8

* Note: For side or back-lighted subjects in bright sunlight, use ½ to 1 stop more exposure to record shadow detail.

Figure 2-1. A daylight exposure table.

b. Orthochromatic film is the best type of film to use when photographing on an average hazy day.
c. Maximum haze penetration can be achieved by using infrared film and a red filter.

2-2. Data Guide Charts

Your value to a photographic facility is increased when you overcome problems that could result in an assignment failure. For example, you may be faced with an accident assignment during which your light meter is damaged or is giving false readings. If your technical background is shallow, or you have not developed the ability to judge light conditions, you will most certainly have problems in getting the proper exposure. In this section, we discuss the exposure guides which can help you calculate exposure settings when you do not have a light meter.

217. Given lighting and subject conditions, calculate the correct exposure using the exposure guide presented in figure 2-1.

The problem of calculating the exposure for any subject involves the interrelation of two factors: the speed of the film and the brightness of the subject. We use the ASA film speed indexes for our exposure computation of speed. Two methods of judging brightness are visual estimation and the use of an exposure meter. Both have their individual merits, though for consistent results under a variety of conditions only a properly working exposure meter should be used.

Visual Estimation. Visual estimation is based on past experience with films of a given speed and by personal judgment of scene brightness. Because of the characteristics of the human eye, such brightness judgments are seldom very precise even though experienced photographers can become quite skilled at making visual estimations under familiar conditions.

In the absence of an exposure meter, the following system can be used to calculate a fairly accurate camera exposure outdoors. The basic shutter setting is the reciprocal of the film speed. If the film's ASA rating is 125, use 1/125 second as the shutter speed; if the speed is 250, use 1/250 second; and so forth. Your basic f/stop setting can be selected by using an exposure table. Many film packages contain tables such as the one shown in figure 2-1.

Using an Exposure Table or Guide. Completely accurate assessments of lighting conditions are seldom possible. However, most film emulsions have sufficient latitude to cover any minor error you might make. Consider the following statements as aids in assessing light conditions by visual estimation.

a. A bright sun and clear sky produces deep dark shadows of subjects in the scene. Use the Bright Sun column for exposures under these conditions.

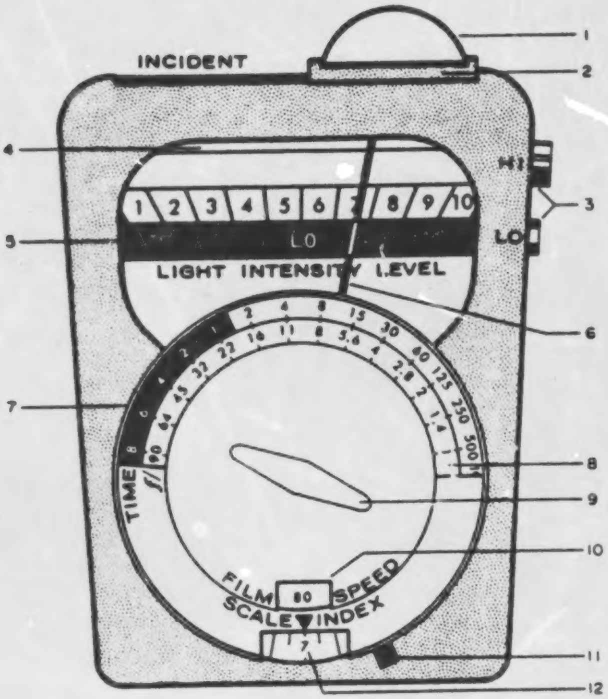
b. If the sun's outline is visible behind a thin veil of clouds, use the Hazy Sun column. In this case, the sun's brightness has been softened somewhat by a fine haze over the sky or by thin clouds. As a result, the shadows of objects are light and transparent.

c. If you can't see the sun and the sky is bright in the direction that the sun should be, use the Cloudy Bright column. Many overcast days when the sun is hardly visible can be included in this classification. Shadows of ground objects under these conditions are barely visible.

d. In the event the whole sky is covered with dark clouds, use the Open Shade column. This classification also applies when your subject is standing in the shadow of another object. By open shade, we mean it is possible to see the clear sky overhead from the subject's position. In other words, your subject is standing in the shade of another object, and this shade is fairly even over the entire area where your subject is located.

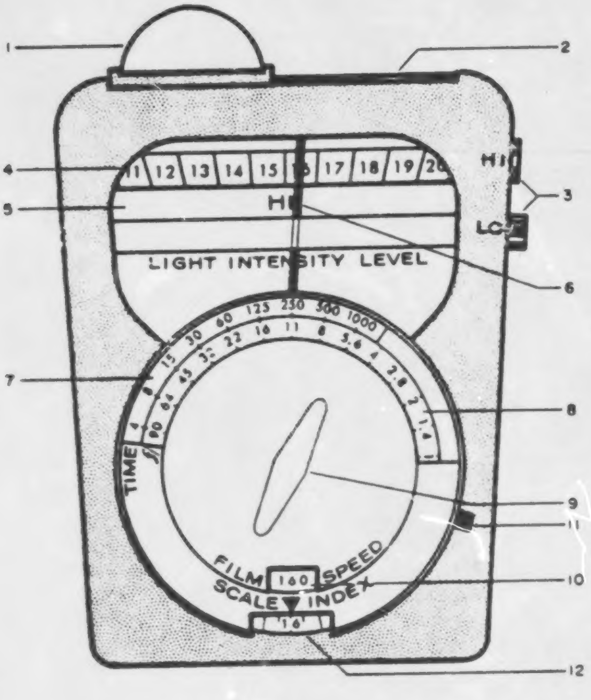
e. Use the Deep Shade column when supplemental lighting of subjects in deep shade is not possible. Use extra care in making photographs in deep shade to ensure adequate shadow detail.

Next, turn your attention to the subject brightness. If it is a general snow scene or a beach scene with a lot of reflection throughout the entire area, use the top row labeled *brilliant*. If your main subject, within the snow or beach scene, is not reflecting very much light because the subject is dark colored, use the second row of f/stops labeled *bright*. Also, use this classification when you estimate that the general scene is reflecting more than 50 percent of the light striking it. Most of the subjects you will be photographing can be classified as *average*. This means that they reflect 15 to 50 percent of the light striking them. When it appears to your eye that the subject is reflecting less than 15 percent of the light striking it, use the last row of f/stops labeled *dark*.



1 INCIDENT LIGHT SPHERE
2 REFLECTED LIGHT APERTURE (COVERED BY SPHERE)
3 ILLUMINATION SELECTOR BUTTONS
4 HIGH INTENSITY ILLUMINATION SCALE (OUT OF VIEW)
5 LOW INTENSITY ILLUMINATION SCALE
6 SCALE INDICATOR NEEDLE
7 EXPOSURE TIME SCALE
8 LENS APERTURE SCALE
9 FILM SPEED SELECTOR
10 FILM SPEED INDEX WINDOW
11 INTENSITY SCALE INDEX LEVER
12 INTENSITY SCALE INDEX WINDOW

Figure 2-2. A hypothetical exposure meter set for incident light.



1 INCIDENT LIGHT SPHERE
2 REFLECTED LIGHT APERTURE
3 ILLUMINATION SELECTOR BUTTONS
4 HIGH INTENSITY ILLUMINATION SCALE
5 LOW INTENSITY ILLUMINATION SCALE (HIDDEN)
6 SCALE INDICATOR NEEDLE
7 EXPOSURE TIME SCALE (ROTATES WITH INTENSITY SCALE INDEX)
8 LENS APERTURE SCALE (FIXED)
9 FILM SPEED SELECTOR
10 FILM SPEED INDEX WINDOW
11 INTENSITY SCALE INDEX LEVER
12 INTENSITY SCALE INDEX WINDOW

Figure 2-3. A hypothetical exposure meter set for reflected light.

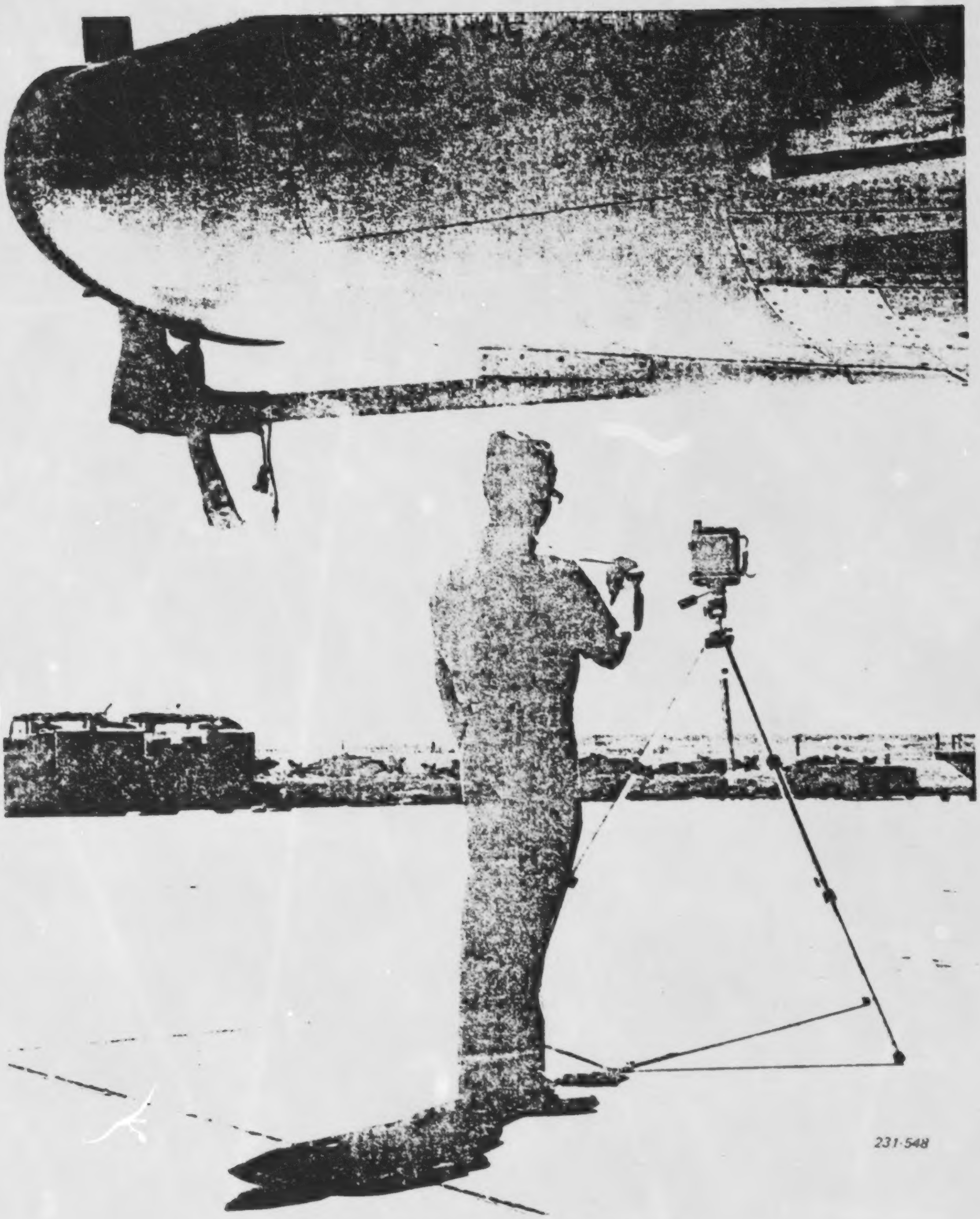


Figure 2-4. Taking an incident meter reading.

55

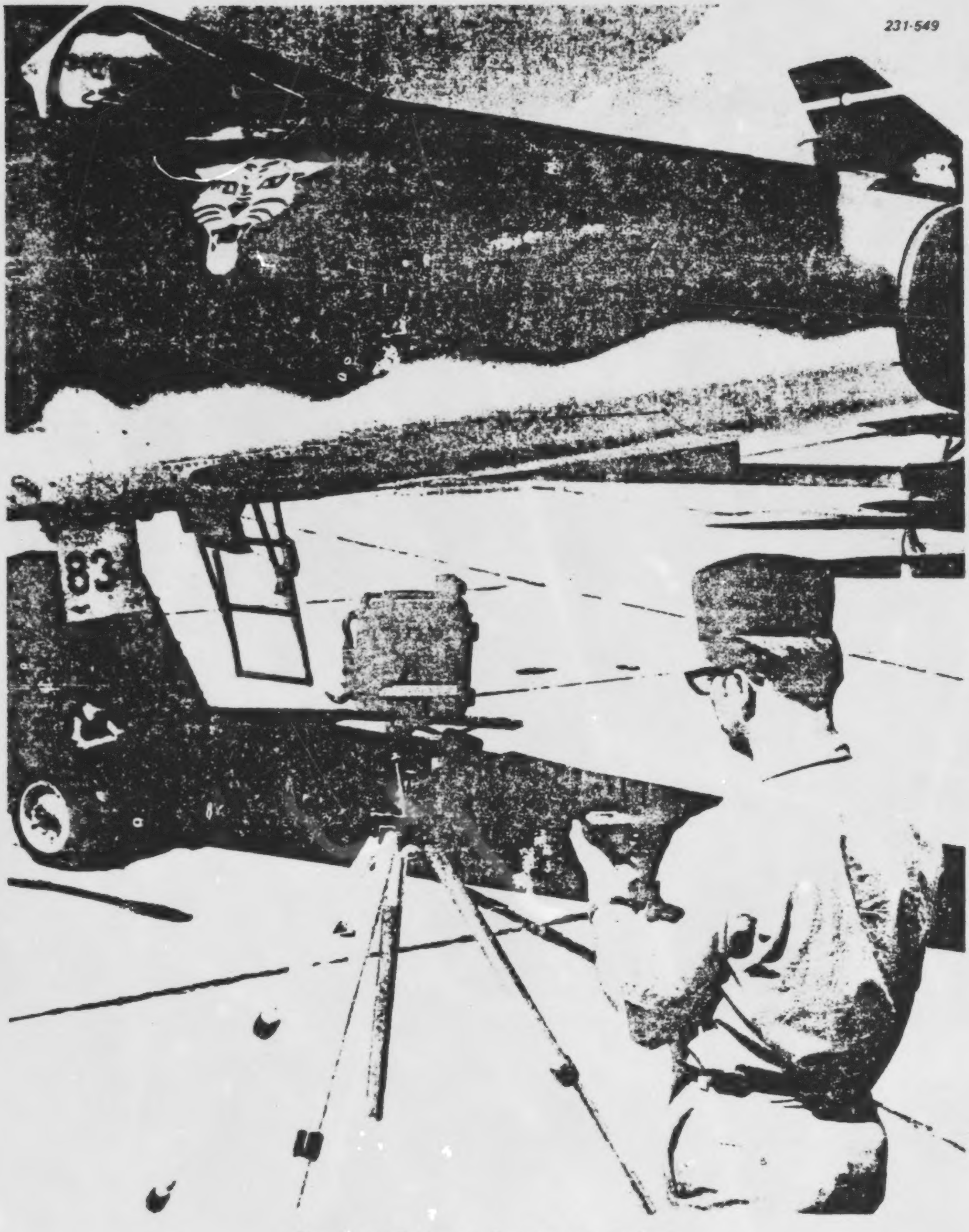


Figure 2-5. Taking a reflected meter reading.

Let us try to put everything together by working a problem. Suppose you are photographing a cream-colored building. First, you look at the sky in the direction of the sun. You discover the light condition to be "hazy sun" since you are able to see the outline of the sun through a thin veil of clouds. Since the building is cream colored, you then select "bright" for the subject brightness. At the point on the table where the columns for bright subjects under hazy sun intersect, you find f/16 to be the basic aperture setting. If you are using film with a speed of 125, the basic exposure would be 1/125 at f/16.

Exercise (217):

1. With the aid of figure 2-1, select the appropriate f/stop for each one of the following shooting situations.
   a. Photographing a snow scene on a day when the sun has been softened by thin clouds.
   b. The subject is a black automobile. The sky is overcast.
   c. Photographing a young girl under a tree on a sunny day.

2-3. Exposure Meters

The human eye is a poor instrument for measuring the critical intensity of light. Because of this, we must rely on exposure meters for accurate light measurements. In this section we cover principles, maintenance, and application of exposure meters.

218. State the purpose of reflected and incident light exposure readings and complete statements concerning the use of exposure meters.

Exposure meters are light-sensitive measuring devices which convert light energy into electrical energy on a proportional basis. Exposure meters employ two systems for making light intensity readings. The *incident* method measures the intensity of light falling on the subject. The *reflected* method measures the amount of light being reflected by the subject. Many meters today are convertible to either method. For the sake of discussion, we will examine each method separately.

Incident-Light Meters. The incident-light meter measures the light falling on the subject. This type of meter does not consider the tone value of the subject at all. Thus, it does not read the amount of light being reflected by the subject toward the camera. If you use this type of meter, you must take into consideration the tonal value of the subject to understand the scene brightness range you are working with.

Many of the modern exposure meters can give either incident or reflected light readings. Photoelectric exposure meters operate on a common principle and, as shown in figures 2-2 and 2-3, vary primarily in their configuration for use. Light falls on a photoelectric cell which responds by creating electrical current. The cell produces power in direct relation to the intensity of the light it receives and moves a needle that indicates light intensity on a scale for exposure computation. The more light there is, the greater is the deflection of the needle. In addition, the meter has a set of dials which, when set according to the proper film-speed index and the scale reading of light intensity, gives the exposure directly—depending on the shutter speed or diaphragm opening desired.

Figure 2-2 shows the incident-light sphere in place over a window that gathers light for the photoelectric cell. The sphere receives the light from above, below, forward, and the sides. When held at the subject position and pointed toward the camera (as in fig. 2-4), an incident-light meter measures the light falling on the subject.

Reflected-Light Meters. Figure 2-3 illustrates a meter configuration for reading high intensity reflected light. Individual components are identified by the same figures used in figure 2-2. However, you should note that the sphere (1) has been pushed aside to reveal the reflected light aperture (2) forward of the photoelectric cell. The illumination selector (3) has been set for readings on the high-intensity scale (4). Film speed 160 has been set in the index window (10).

Figure 2-5 illustrates the principle of reading with the reflected light exposure meter. It measures the amount of light being reflected toward the camera by the subject. Thus, this type of meter actually measures the picture-producing light. This is the most important feature of this type of light. You can use this meter to measure the scene brightness range by taking separate readings of the highlight and shadow portions of the subject.

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Exercises (218):

1. What is the purpose of taking a reflected-light meter reading?

2. Explain the reason for taking an incident-light meter reading.

3. Complete the following statements regarding the operation of exposure meters.
   a. When using a reflected meter, you point the meter toward the__________.
   b. The tonal values of the subject are not measured when taking ___________ meter readings.
   c. When using an incident meter, you point the meter toward the_____________.
   d. __________ meter readings are used to measure the scene brightness range of the subject.

219. Identify principles and techniques that apply to different types of meter readings.

Reflected Meter Techniques. A reflected meter is used to measure light that is being reflected by the subject towards the camera. The meter is programmed to yield a reading that will reproduce a middle gray tone. This is to say that if you measure the light being reflected by a certain subject and use this reading for your exposure and then process and print your film correctly, the subject will appear a medium gray. All other parts of the scene that reflected more or less light than this subject will be lighter or darker tan middle gray. It is most important to realize that a middle gray tone may not be the best representation of the subject and that you may have to modify your exposure to achieve the right tone.

When taking a reflected light reading, it is important to know exactly what part of the subject the meter is reading. Each type of meter has its own angle of acceptance. Some meters read a very narrow area (such meters are often called "spot" meters) while others read a very wide angle. It is possible for a meter to read too much of the shadow or highlight areas and cause an inaccurate exposure. Therefore, it is a good idea to move in close to the subject so that you can make sure that the main subject is being measured.

There are basically three types of readings made with a reflected meter. These are: (1) average, (2) brightness range, and (3) substitute. Let us see how each works.

Average reading. To take an average reading, you simply aim the meter toward the middle of the subject and take a reading. This averages the highlight and shadow areas to give you a "middle" reading. This type of reading works well with average contrast subject.

Brightness range. To take a brightness range reading, you first take a reading of an important highlight area. Next, take a second reading by measuring an important shadow area. Then average these two readings to get your exposure. For example, if the highlight measured f/22 at 1/125 and the shadow was 5.6 at 1/125, your exposure would be f/11 at 1/125.

Substitute reading. If you cannot approach the subject to measure its reflectance, you can select some object that closely approximates the subject's reflectance and use it to compute exposure. If the substitute object is lighter or darker than the subject, you must make a minor adjustment before making the exposure. If the subject is a person, for example, you could take a reading off the palm of your hand and use this reading to produce a good exposure. Remember, however, the substitute object must be illuminated by light having the same quality and intensity as that used to illuminate the subject. (You can use an 18-percent neutral gray test card to make substitute readings. This technique is discussed in a subsequent section.)

Incident Meter Reading. When using an incident light meter, point the light-gathering receptor toward the camera. The meter averages all of the light falling on the subject. This type of metering is valuable when you have contrasty or back lighted subjects where the strong highlights might cause erroneous reflected readings.

Exercises (219):

1. What is the difference between an average and a scene brightness reading?

2. When would it be a good idea to use an incident light meter reading?

3. What factors should be considered when choosing a substitute subject for a reflected meter reading?

220. Complete statements about the proper use and care of an exposure meter.

Care of Exposure Meters. Your exposure meter will last for a long time provided you don't drop it or otherwise abuse it. To ensure utmost accuracy, you should follow the appropriate operator's checklist and instructional booklet provided by the manufacturer. You should also consider the following points:

(1) Clean the glass over the photoelectric cell before use.
(NOTE: In dry weather, you may find that rubbing the glass with cloth can generate a static electricity charge and cause the needle to give a false reading. You can remove the charge by breathing on the glass.)

(2) Zero the meter. Cover the meter cell opening to cut off all the light. (With some meters you must remove the batteries.) The needle should be at 0 or at an appropriate zero mark. Tilt the meter in various directions—from side to side and up and down. The needle should not move more than the equivalent of one-third of an f/stop despite the position of the meter. If needed, adjust the needle until it zeroes.

(3) Check for sticky movement. Aim the meter cell at any light source until the needle is at about the halfway mark on the scale. Cover the cell and uncover it several times. The needle should go to 0 each time the cell is covered. Even with low light intensity, the meter pointer should move smoothly.

(4) Check for accuracy. Absolute accuracy tests are very difficult, and it is impossible to check for the meter's accuracy every time you go on a camera mission. However, you should assure that your meter indicates exposures which are logical on the basis of your experience or which match those indicated by another meter of known accuracy.

Always handle your meter correctly since the quality of your photographs depends on correct exposure metering. Consider the following operational DOs and DON'Ts.

DO—Protect the meter from bumping against other objects. Carry the meter in your pocket or camera case when it isn't in use. The meter case gives some protection, but is not adequate for safety in extreme conditions.

DON'T—Subject the photoelectric cell to light intensities above those that are programmed by the selector switch. Extreme intensities may cause the indicator needle to bounce at the high end of the scale and eventually cause damage to the unit.

DON'T—Subject the exposure meter to temperatures above 125° F. When you are not using the meter, keep it in the carrying case and away from heat.

DON'T—Point the photoelectric cell toward the sun. The cell may be "blinded" and give erroneous readings for many hours.

Exercise (220):

1. Complete the following statements on the proper care and use of an exposure meter.
   a. A photoelectric meter can be ____________ if you point the meter toward the ______________.
   b. Subjecting a meter to very ____________ intensities of light can cause permanent damage.
   c. The meter should be protected from ___________ other objects.
   d. In most meters, when the batteries are removed the needle should rest at the ___________ mark.
   e. Protect your meter from temperatures above ___________.

2-4. Neutral Density Gray Card

There are times when the subject is so small that it is impossible for adjacent areas to be excluded from the exposure meter's field of view. Under these conditions, the meter may provide inaccurate exposure data. At other times, it is impossible to approach the subject in order to take a meter reading. Finally, there are situations when the subject is not available for you to make exposure readings. For example, it is not possible to interrupt sports activities in order to take a closeup reading. Under these and other conditions, a neutral test card can be substituted for the subject to assist you in calculating the correct exposure.

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Figure 2-6. Using the gray card.

221. Identify correct and incorrect statements about the proper use of the gray card.

The neutral-test card is approximately 8 x 10 inches in size, gray on one side and white on the other. The gray side reflects 18 percent of the light incident on it, while the white side reflects 90 percent of the light that strikes it.

There are three basic rules to be remembered when using a gray card:

(1) The illumination falling on the card must be of the same quality and intensity as that falling on the subject.

(2) When you are using a gray card to estimate exposure, be sure to hold the meter close to the card. This way, light from surrounding areas will not strike the meter's cell and produce erroneous readings.

(3) Make sure that the card is held perpendicular to the ground. If it is held at an angle, either up or down, it will produce inaccurate readings.

To use the gray card correctly, position it properly as shown in figure 2-6, and measure the light reflected from it. Next, compare the reflectance of the card with the reflectance of your subject. If the subject is lighter, select a smaller aperture. If the subject is darker, open the aperture to admit more light.

If you are working under conditions of extremely low illumination, it may not be possible to register a reading on the gray side of the card. However, the white side of the card reflects five times as much light and may provide sufficient reflectance to make an exposure reading. If the white side of the neutral test card is used, you must remember that it shortens the exposure by five times over the reading provided by the gray side of the card. Typical subjects reflect less light than the white side of the neutral test card. If you use the actual exposure data provided from this side of the card, most of your negatives will be severely underexposed. As a general rule, open the aperture approximately 2-½ f/stops over the white side reading.

Exercises (221):

1. Identify each of the following statements as true or false.
   a. The gray side of a neutral test card reflects 18 percent of the light striking it.
   b. You can take an incident reading off a gray card.
   c. When using the white side of the neutral test card, you need to increase your exposure 2½ stops.
   d. When taking a reflective light reading off a gray card, the card should be held at a 45° angle to the subject.

Still/Motion Picture Cameras

THERE IS NO SINGLE camera to fill every photographic requirement. Most photographers choose from among cameras that produce negatives ranging in size from 35mm through 8 x 10 inches. Their choice is dictated by the purpose of the photography and the conditions under which it is to be accomplished.

Small cameras are essential when the photographer requires maximum freedom of movement. With very little manipulation of the camera, they permit making several exposures in rapid succession on roll film. Accessories, such as special purpose lenses and flash equipment, are easily carried by the photographer. However, small cameras have a disadvantage in their small negative size. Extreme care in exposing and processing is required to retain fine detail with small negatives. Corrections in the image by retouching are virtually impossible to make.

Large cameras are usually used when you must retain maximum detail in the negative without special processing. This is necessary when certain subjects are photographed to an exact scale or when very large-scale reproductions are needed. Correction of certain faults in image detail is possible with large sheet film negatives. The disadvantages of large cameras are their bulk and the need for heavy-duty tripod support. Large supplementary lighting equipment further reduces portability.

Between the two extremes just described are larger roll film cameras and smaller sheet film cameras. These are, to a great extent, universal in their use. Negatives produced by these cameras are large enough to retain good detail without special processing techniques. Their size allows the photographer to carry most accessories conveniently.

How many of each type of camera a photo lab needs depends primarily on the lab's mission. All cameras have features in common and, once you have become familiar with the operation of one camera, you can easily learn to operate other types. We will, therefore, discuss examples of cameras that fall within

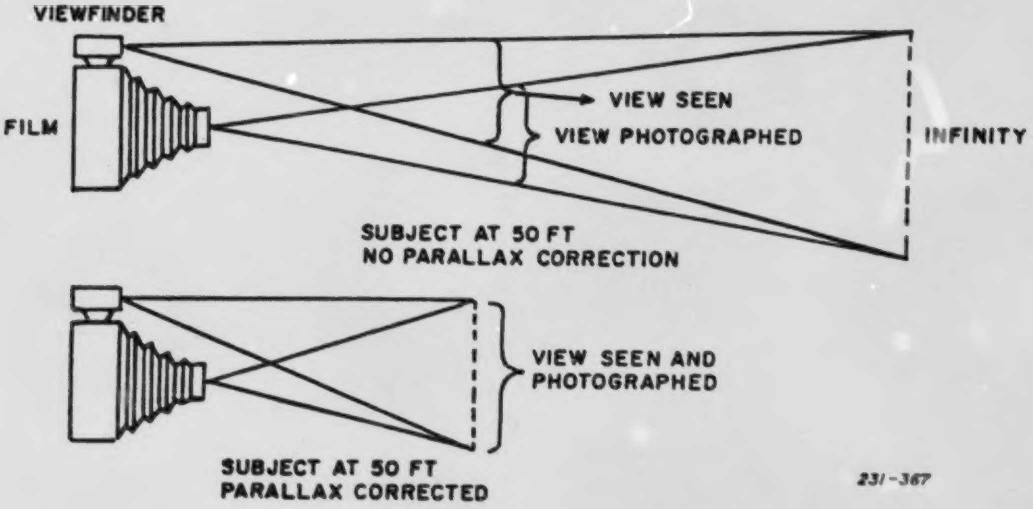

Figure 3-1. Parallax correction with optical viewfinder.

the following categories: (1) reflex, (2) 35mm SLR/RF, (3) press, (4) view, (5) copy, and (6) duplicating cameras.

In addition to still cameras, many base photo labs have a limited requirement for cameras to produce 16mm motion picture footage for television news release. In light of this, a short discussion of motion picture camera operation is also given.

3-1. Reflex Cameras

The reflex camera is not really a different type of camera. The difference between reflex cameras and other cameras is their unique method of viewing and focusing the subject. In this section we distinguish between the single lens and twin lens reflex systems and discuss the operation of the "Rolleiflex" camera.

222. State the basic differences between the single lens and twin lens reflex camera systems.

Single Lens Reflex Camera. Many cameras suffer from parallax. Parallax occurs when there is a difference in the angle used to view the subject and the lens angle of coverage. Parallax becomes more of a problem as the camera moves closer to the subject. Pictures in which part of the subject is cut off can usually be blamed on parallax. Figure 3-1 illustrates the problem.

The *single lens reflex* camera does not have a parallax problem. A mirror in the path of the image formed by the lens deflects the light from the subject to the viewing screen for focusing and composition. Thus, the photographer is able to see what the lens sees regardless of the focal length of the lens or the lens-to-subject distance.

When the shutter is tripped, the mirror moves out of the way and allows the light to pass to the focal plane, where it exposes the film. Usually, the mirror instantly returns once the exposure is finished. Figure 3-2 illustrates the principle of operation of the single lens reflex camera.

Twin Lens Reflex Camera. The *twin lens reflex* design combines two separate lens systems into a single camera. The top lens is for viewing and focusing, while the bottom lens takes the picture. The top lens focuses an image of the subject on the viewing screen in much the same manner as the single lens reflex camera, except that the image is reversed. The twin lens reflex camera suffers from parallax at close distances. Parallax correction may be obtained by internal compensation between the two lenses or by a bar that comes across the viewing screen indicating the reduced area covered by the taking lens. Figure 3-3 shows the twin lens reflex principle.

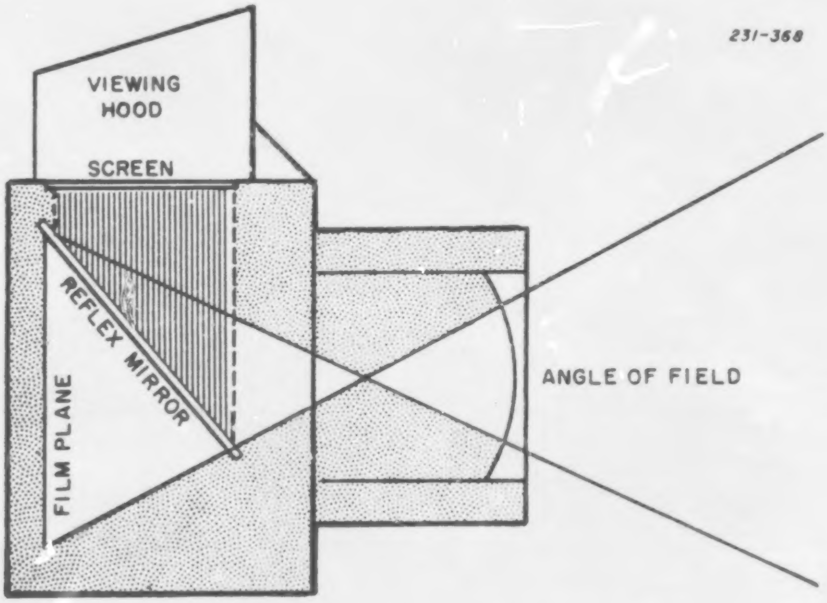

Figure 3-2. Principles of typical single lens reflex camera.

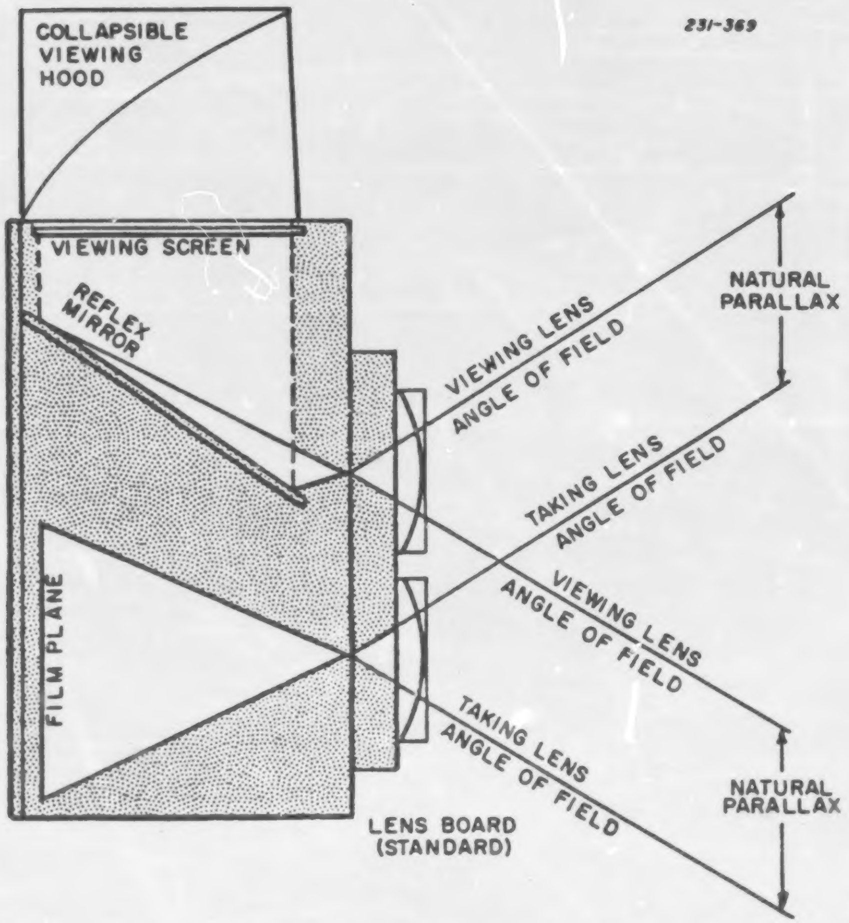

Figure 3-3. Principles of twin lens reflex cameras.

Exercise (222):

1. State the basic differences between the single lens and twin lens reflex camera systems.

223. Complete statements about features and procedures related to the "Rolleiflex" camera.

The "Rolleiflex" Camera. Shown in figure 3-4 is the "Rolleiflex," the twin lens camera you will most likely use. It uses both reflex viewing and focusing, and it has an open frame viewfinder for use when you are shooting sports or action.

The major features of the "Rolleiflex" are:

- A f/2.8, 80mm lens.
- Shutter speeds from 1 second to 1/500 second and bulb.
- Built-in flash synchronization for both M and X.
- Uses 120 (12 shots) or 220 (24 shots) film.
- Integrated exposure meter with adjustments for film speed and filter factors.
- Rapid wind film advance.

Loading the camera. Follow these procedures to load the camera with 120 film:

(1) Turn the safety back lock clip near the tripod socket and release the back lock lever.

(2) Lift the back open and inspect all internal surfaces for cleanliness. Metal guide rollers and film format surfaces must be free of foreign particles and must not be scratched or blurred in any manner.

(3) Adjust the film guide plate to assure the inscription 2¼ x 2¼ inches is visible and the springback is free to function.

(4) Place an empty 120 film spool over the winding key at the side of the spool chamber.

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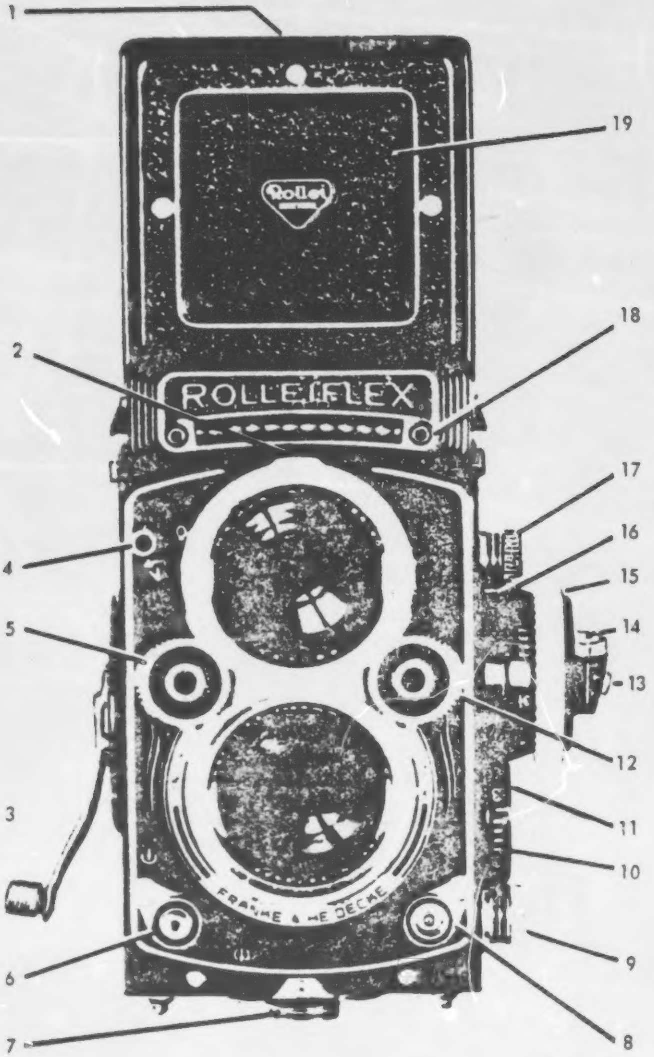

(1) FOCUS MAGNIFIER
(2) SHUTTER SPEED INDICATOR
(3) CRANK KNOB
(4) SELF TIMER AND SYNCHRO FLASH LEVER
(5) SPEED SELECTOR WHEEL
(6) SHUTTER RELEASE
(7) CAMERA BACK LOCK LEVER
(8) FLASH CONNECTOR SOCKET
(9) LOWER FILM SUPPLY SPOOL KNOB
(10) FILTER SCALE
(11) FILM SPEED KNOB DIN/ASA
(12) DIAPHRAGM CONTROL WHEEL
(13) FILM TYPE
(14) AUTOMATIC EXPOSURE INDICATOR
(15) FOCUSING KNOB
(16) "DEPTH-OF-FIELD" SCALE
(17) UPPER TAKE-UP SPOOL KNOB
(18) BUILT-IN EXPOSURE METER
(19) SPORTS FINDER PANEL

Figure 3-4. The Rolleiflex camera.

Pull out the takeup spool release knob and let the spool fall into position. Let the knob snap back into position.

(5) Turn the film transport crank until the long slot in the spool is uppermost.

(6) Place a roll of film in the feed spool chamber at the other end of the camera. The tapered end of the backing paper should point in the direction of the takeup spool, with the paper coming off of the top of the spool. Pull out the supply spool release knob to allow the spool to drop into place and then let it snap back into place.

(7) Remove the tape seal from the roll film. Thread the beginning of the backing paper between the rollers of the film feeder mechanism as shown in figure 3-5.

(8) Using the crank for correct positioning, push the paper leader into the long slot of the takeup spool.

(9) While backing the full spool with the thumb, tighten the backing paper by one-half turn of the crank.

(10) Press the camera back with the palm of the hand to close, fold down the back lock lever, and secure with lock clip.

(11) Turn the crank handle clockwise for 4 or 5 turns until a definite stop is reached. The frame counter now turns automatically to number 1.

(12) Reverse the crank until it stops again and turn it over on its hinge to store.

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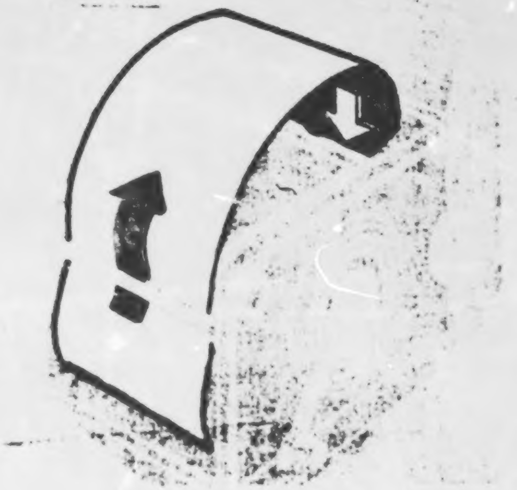


Figure 3-5. Loading the camera.

Setting exposure. The DIN/ASA selection and filter compensating scale are both directly coupled to the automatic exposure indicator located on the left side of the camera (see fig. 3-4). Therefore, always make certain that the film being exposed has the listed ANSI (ASA) rating properly selected, with the filter factor scale on zero. To do this follow these steps:

(1) Gently press and turn the knurled knob until the corresponding speed rating number appears in the ASA window. Dots correspond to intermediate film speeds like 80, 125, etc.

(2) The film compensating number on the outer scale must be set on zero for normal use without filters. When using "Rollei" filters, select the number appearing on the filter ring. These numbers are for "Rollei" filters ONLY. They do not indicate the factor for any other make of filter. *When using other than* "Rollei" filters, compensate manually with diaphragm/shutter speed adjustments.

(3) Turn the knurled knob at the focusing knob to set the film type. This is only a reminder to show which type of film (daylight color, color negative, or black and white) has been loaded.

These three steps are reviewed in figure 3-6.

Focusing and viewing. Follow the steps shown below when focusing and viewing:

(1) Open the hood by pushing up slightly on the rear edge of the hood cover. A spring causes the hood to snap open the rest of the way.

(2) Turn the focusing knob back and forward until the main subject appears sharp on the screen.

(3) The magnifier may be snapped out into position for critical focusing.

Setting shutter speeds and lens apertures. The shutter speed is set by turning the shutter speed selection wheel. Available speeds are 1, 1/2, 1/4, 1/8, 1/15, 1/60, 1/250, and 1/500 plus B. The speed control has click stops so that intermediate values between those marked cannot be used. The opening and closing of the diaphragm is controlled by the lens aperture selection wheel. Both the shutter speed and the aperture setting can be seen from above when you are using the normal viewing position.

Exposing. After having focused and composed the scene and made the exposure settings, hold the camera steady and gently squeeze the shutter release. As soon as the release has been pressed and the "click" felt as the shutter blades open and close, the winding mechanism becomes free, and the crank handle may be turned again until a stop is felt. A three-quarter turn forward advances

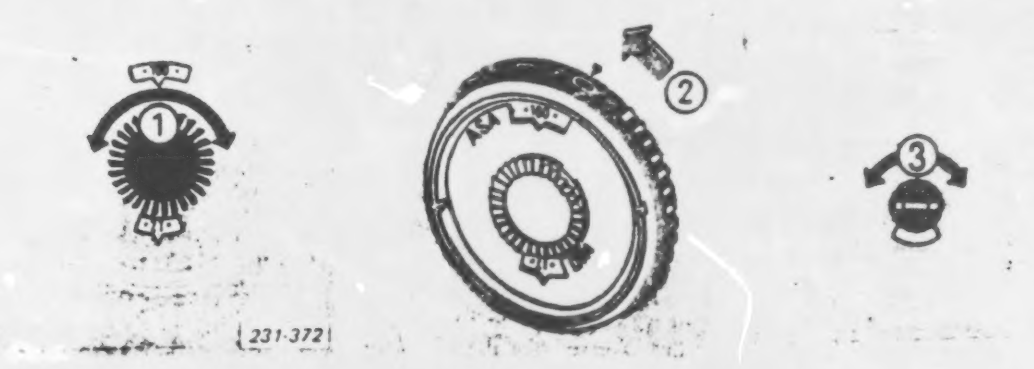
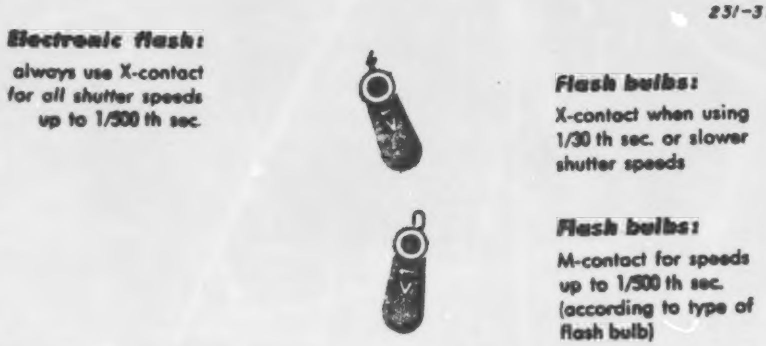


Figure 3-6. Setting the exposure.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Electronic flash:
always use X-contact for all shutter speeds up to 1/500 th sec.
Flash bulbs:
X-contact when using 1/30 th sec. or slower shutter speeds
Flash bulbs:
M-contact for speeds up to 1/500 th sec. (according to type of flash bulb)

Figure 3-7. Flash selector.

the film and turns the counter to the next number. A three-quarter turn back cocks the shutter and permits stowing the crank handle again. After the twelfth exposure on 120 film has been made, no stop is felt as the crank is wound.

Flash operation. The shutter is fully synchronized for high-speed electronic flash as well as flash bulbs. Select the proper contact by raising the small knurled knob and swinging the synchro lever to the desired position, as shown in figure 3-7.

The flash cord connection is located on the front lower left corner. Insert the tip into the flash connector socket. To disconnect the flash cord, swing the locking lever downward and remove the tip from the socket.

Use of the sports finder. Fast moving objects, races, and sports events can be followed and photographed more conveniently by using the direct viewfinder. To use the finder:

(1) Press panel inward all the way to open the sports finder.

(2) Tap both sides of the hood gently to close.

Figure 3-8 illustrates these two steps.

Always use the direct viewfinder close to the eye and look directly at the subject.

Operator Maintenance. A camera is a precision instrument and deserves proper operation for dependable results. Protection throughout its operation is essential. Moisture, dust, sand, water, and strong sunlight are harmful to parts and the lenses. To remove dust from optical surfaces, such as a lens, focusing screen, reflex mirror, or magnifier, use a brush. Then wipe off smears or fingerprints with lens tissue. Remove dust and dirt from the interior parts with air blasts from an aerosol can.

Exercise (223):

1. Complete the following statements on the operation of the "Rolleiflex" camera.
   a. When using 120 in a "Rolleiflex," you get __________ exposures.

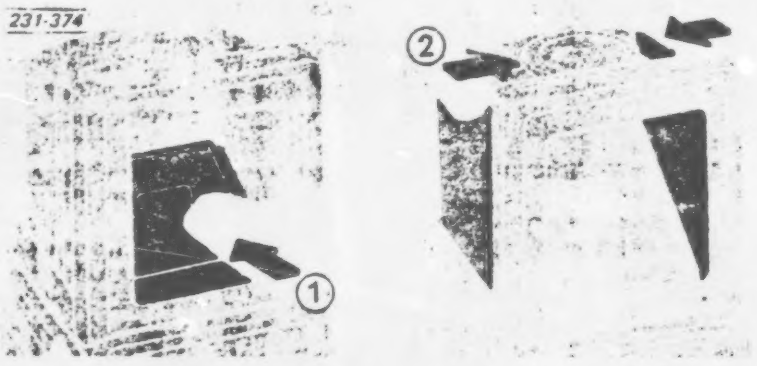


Figure 3-8. The sports finder.

b. Prior to loading film, all internal surfaces should be checked for __________.

c. For accurate exposures, the "Rolleiflex" has a built-in ____________.

d. The "Rolleiflex's" exposure meter has compensating numbers for ________.

e. For critical focusing you should use the built-in __________.

f. The shutter speed selection wheel has __________ __________ so you cannot use any intermediate values.

g. When using the "Rolleiflex," the winding crank must be turned __________ to advance the film and turned __________ to cock the shutter.

h. When photographing action shots, you should use the ____________ __________ to compose the subject.

i. You should use ____________ __________ to wipe fingerprints from a lens.

3-2. 35mm SLR/RF Cameras

Probably the most important advantage of 35mm cameras is the ease with which they can be used. Their small size and compactness make it possible for photographers to carry them strapped around their neck or over the shoulder. Little preparation is necessary to put them into operation. Another advantage is the rapid film changing devices incorporated into the cameras. This can be used to great advantage when it is necessary to take many photographs in a short period of time. Design of the average 35mm camera is such that minimum time is required for making the settings and transporting the film.

Because most 35mm cameras make as many as 36 exposures (250 with a bulk film back) on a single roll of 35mm film, they offer great economy of operation. The photographer can carry enough film in one pocket to make many exposures. This type of camera is helpful for news and action photography where many pictures must be made in a short time. It is also indispensable for color slide work.

35mm cameras usually feature either rangefinder or single lens reflex methods of focusing. In this section we discuss the operation of the "Leica" M-2 which illustrates the first type and then the "Nikon" F which is a single lens reflex.

224. Complete statements about the operation of the "Leica" M-2.

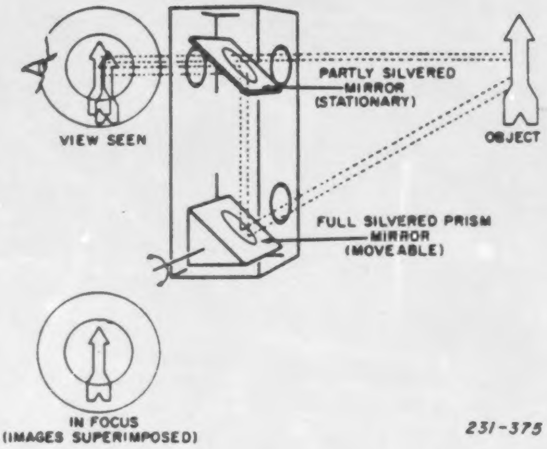

PARTLY SILVERED MIRROR (STATIONARY)
VIEW SEEN
OBJECT
FULL SILVERED PRISM MIRROR (MOVEABLE)
IN FOCUS (IMAGES SUPERIMPOSED)
231-375

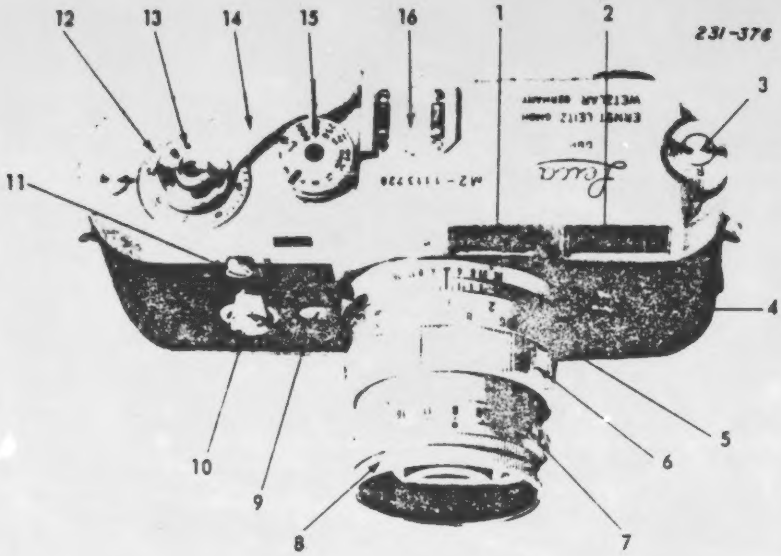
Figure 3-9. Principles of double image rangefinder.

Rangefinder Focusing. The rangefinder method of focusing (coupled in a viewfinder for composing), illustrated in figure 3-9, has several advantages. As it does not depend on light passing through a lens for viewing and focusing, it can, through the use of a silvered mirror, display quite a bright image. Such focusing is of great advantage in low light conditions often found in news and combat situations. Furthermore, since there is no moving mirror, the camera can be extremely quiet which is a big help with sensitive subjects.

Its major disadvantage, which is responsible for its decline in popularity, is that the rangefinder is effective only over a small range of focal lengths. Most 35mm rangefinders can only be coupled to lenses from 21mm through 135mm. For shorter than 21mm focal lengths, reliance must be made on the lens scale for focusing. For focal lengths greater than 135mm, an accessory reflex housing has to be used. This limits the camera's advantage of small size and ease of use. Another disadvantage is that a rangefinder system can suffer from parallax at close lens-to-subject distances. Finally, the rangefinder can get out of synchronization. This produces out-of-focus negatives that unfortunately may not be discovered until the film is processed.

Still, when used with a short focal length lens, a 35mm rangefinder camera is a small, sturdy, and fast-handling camera that is ideal for available light photojournalism and combat assignments.

The Leica M-2. The Leica M-2 is a 35mm rangefinder camera. The camera's viewfinder permits the photographer to preview the



1. VIEWFINDER FRAMING WINDOW
2. VIEWFINDER WINDOW
3. REWIND KNOB
4. PREVIEW SELECTOR
5. FOCUSING SCALE
6. FOCUSING RING
7. APERTURE SCALE
8. APERTURE CONTROL RING
9. LENS RELEASE CATCH
10. SELF-TIMER LEVER
11. FILM TRANSPORT REVERSING LEVER
12. EXPOSING COUNTER
13. SHUTTER RELEASE BUTTON
14. FILM ADVANCE LEVER
15. SHUTTER SPEED SELECTOR
16. ACCESSORY SHOE

Figure 3-10. The Leica M-2.

scene at an angle only slightly different from the lens-to-subject angle. A bright outline indicates the coverage of 35mm, 50mm, or 90mm lenses. This outline adjusts automatically with the installation of the lens. The framing outline adjusts to compensate for parallax when the lens-to-subject focus is changed. A 50mm, f/2 lens is the basic lens. Focusing may be accomplished with either the rangefinder or with the focusing scale. A focal plane shutter is automatically cocked with each action of the film advance lever. See figure 3-10 for a description of the camera's basic components.

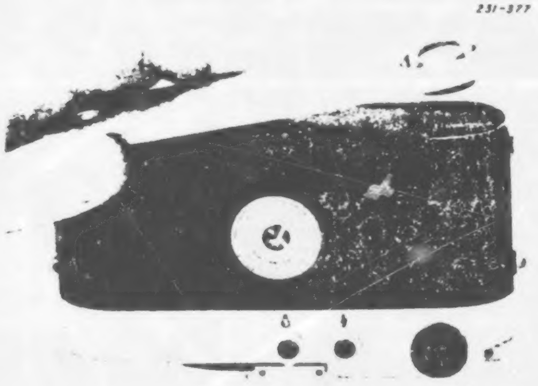


Figure 3-11. Base plate.

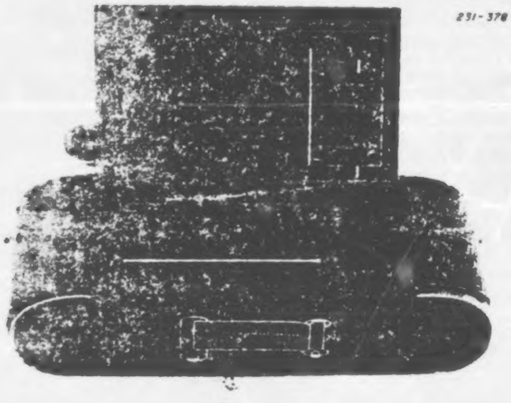


Figure 3-12. Hinged back.

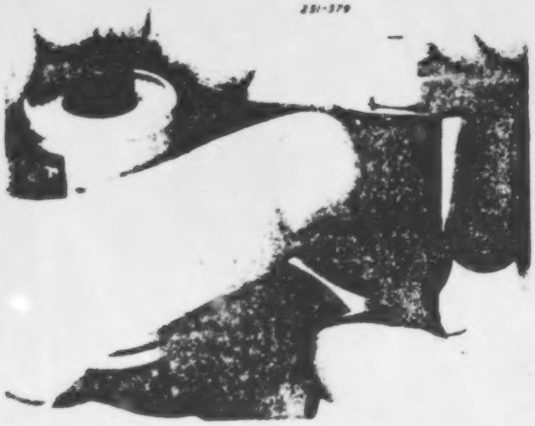


Figure 3-13. Cassette and spool.

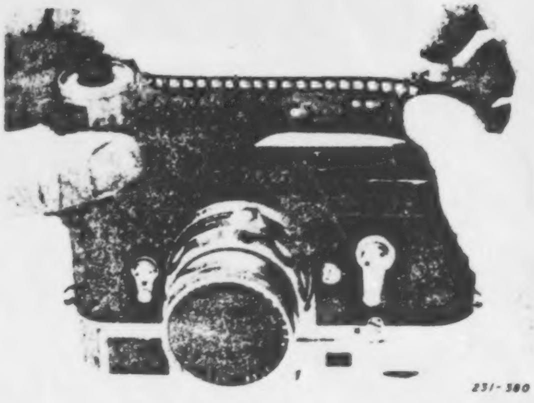


Figure 3-14. Inserting film into the camera.

Loading the camera. Roll film should be loaded under subdued light. Although the cassette normally provides sufficient protection from stray light rays, shading the film from bright light insures against accidental fogging. Keep loaded cassettes in their original containers until they are needed and remember to protect them from excessive heat.

To load the camera, turn it upside down. Then raise the base plate locking key and turn it to the "auf-open" position. Now you can lift off the base plate and open the hinged back (see figs. 3-11 and 3-12). Place the camera, base up, on a clean surface, with the lens facing you.

With the takeup spool in your right hand and the film cassette in your left hand, insert the film leader tab under the takeup spool clamping spring. Be sure to position the cassette and the film spool as illustrated in figure 3-13. Push the film leader tab under the clamping spring. Wrap the film completely around the takeup spool by turning it clockwise for one full turn. Make sure that the edge of the film lies close and straight against the spool flange.

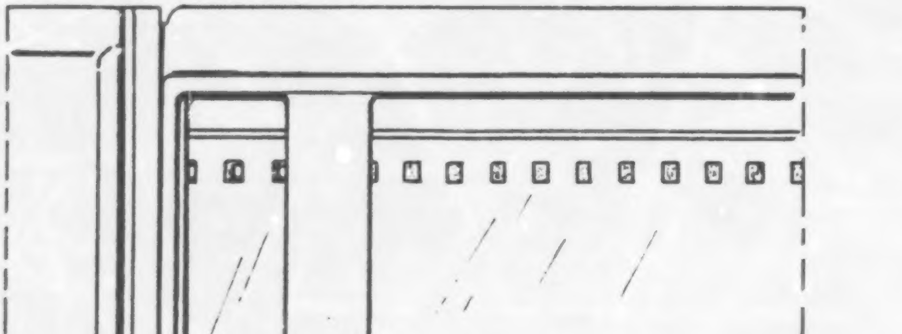


Figure 3-15. Sprocket teeth and film perforations.

Pull enough film out of the cassette to allow the cassette, film, and takeup spool to be inserted into the camera. The film must be loaded with the takeup spool knob positioned as shown in figure 3-14. The film fits into a slot just inside the camera back.

Now, turn the camera so that it rests on the lens and you can view the opened back. Be careful not to damage the lens. If one is available, the lens should be protected by a lens cover.

Check to make sure that the film and spool have been fully inserted into the camera. The edge of the film must be parallel with the guide lines of the film channel. Check also to make sure that the glossy surface of the film base is facing you. If not, the film is loaded incorrectly.

Gently turn the film advance lever just enough to engage the drive sprocket in the film's sprocket holes. Make sure the sprocket teeth mesh correctly with the film perforations, as shown in figure 3-15. Then close the back, replace and lock the base plate, and turn the camera upright.

Complete the advance lever stroke and trip the shutter by pressing the shutter release button. Operate the film advance and trip the shutter one more time to insure that all light-fogged film has been wound onto the takeup spool. Now, set the film counter at "0" and advance the film one more time. This cocks the shutter and positions unexposed film in preparation for the first exposure, now indicated by the number "1" on the film counter. If you wish, you may set the film speed on the indicator on the back of the camera as a reminder.

Advancing the film. The film advance lever (see fig. 3-16) winds exposed film onto the takeup spool and automatically cocks the shutter for the next exposure. The film counter indicates the number of exposures made. However, even though you are using a 20 to 36 exposure roll of film, you may exhaust your film before the counter reaches these numbers. If you fog an excessive amount of film during loading, this could prevent you from making a full 20 or 36 exposures on the roll of film. Remember, if you are approaching the end of the roll and you encounter resistance, DO NOT attempt to force the film advance lever. This can damage the film and could possibly even tear the emulsion. If this happens, the camera must be unloaded in the dark to avoid ruining the exposed film (see fig. 3-16).

During film loading, and periodically throughout camera operation, watch the dots imprinted on the core located in the center of the rewind knob. These dots should rotate as the film is advanced. If they do not, the film is either broken or has come loose from the takeup spool. Remember, if some of the film has already been exposed, it will be necessary to correct the malfunction in the dark.

Setting apertures. Lens apertures are set by rotating the aperture control ring, as shown in figure 3-17. A dot, just forward of the control ring, is used as an index mark for positioning the desired aperture. Turn the control ring until the desired aperture (f/8 in this illustration) is aligned with the index mark. The aperture can be positioned with the index mark set between f/stops. You can do this when the amount of change, produced by

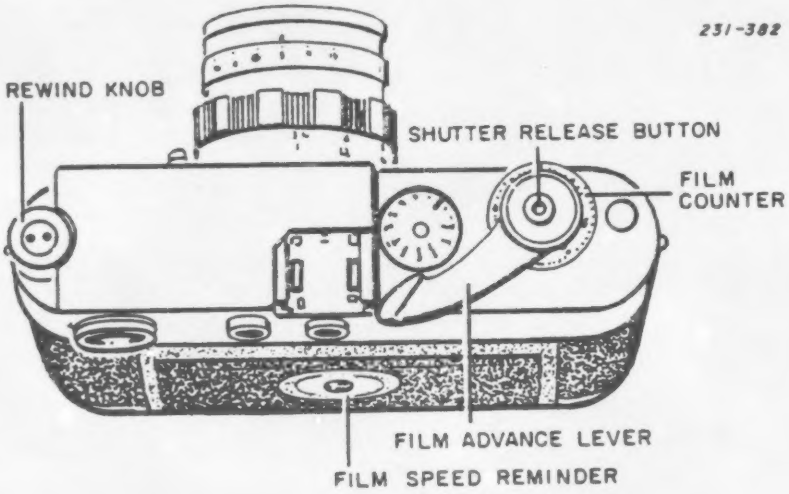


Figure 3-16. Film advance and shutter release button.

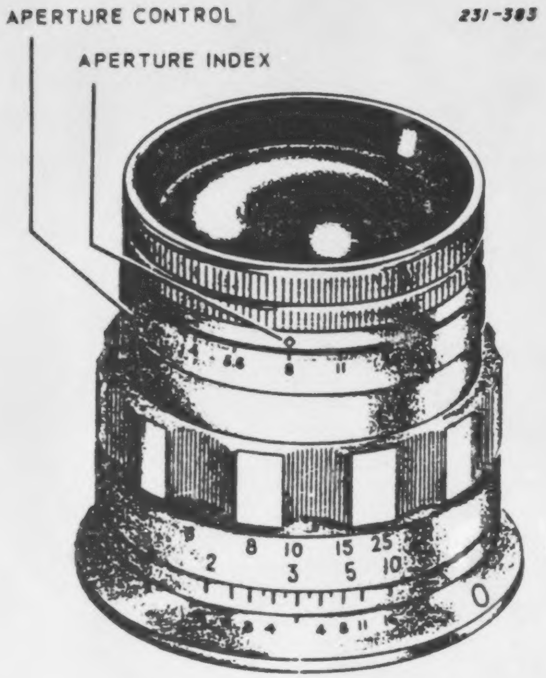


Figure 3-17. Aperture adjusting control.

going from one full stop to the next, exceeds your requirements. These aperture positions are called "halfstops."

Shutter operation. Never attempt to use shutter speeds slower than 1/30 of a second without a tripod. Slower shutter speeds may show camera movement, and unless some type of support is used, blurred images result. Shutter speeds are set by rotating the shutter speed ring, shown in figure 3-18. DO NOT attempt to rotate this ring from the "B" position through the intermediate speed positions in order to reach the 1/1,000 of a second position.

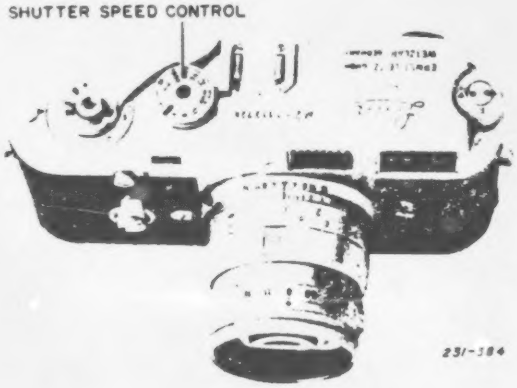


Figure 3-18. Shutter control.

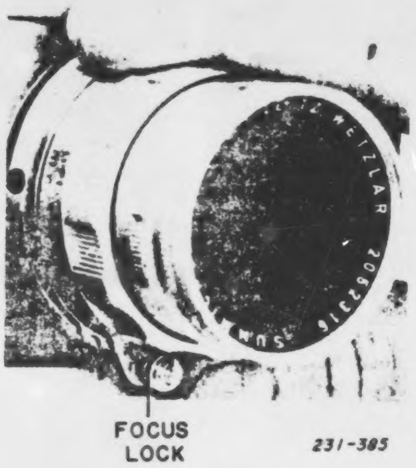


Figure 3-19. Infinity lock.

PRECAUTIONS: Use a smooth and gentle pressure on the shutter release. Good breath control and gentle pressure on the shutter release are as effective in photography as in firing a rifle. Any jerky pressure on the shutter release, especially at slower speeds, may blur the image.

Focusing scale. When the lens is focused on infinity, a button locks the lens into position

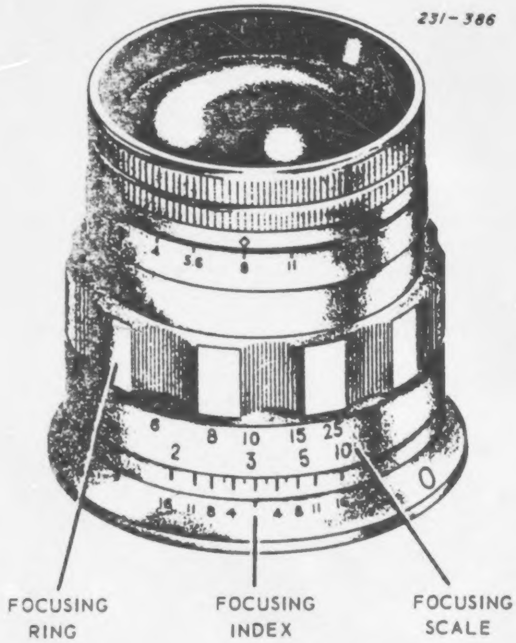


Figure 3-20. Focusing scale.

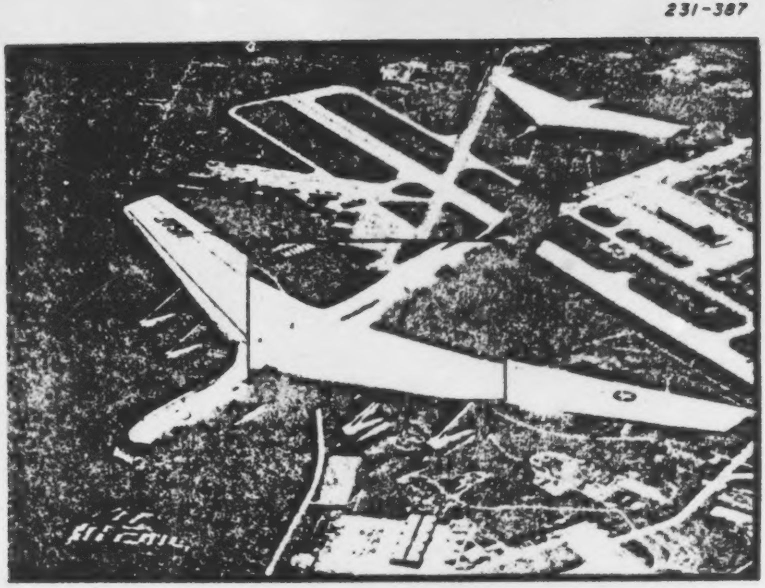


Figure 3-21. Rangefinder focusing.

(see fig. 3-19). To focus the camera at distances other than infinity, the locking button must be disengaged. To use the focusing scale, simply estimate the distance to the subject, and then rotate the focusing ring until the estimated subject distance is aligned with the central triangular index. The focusing ring has two scales. The outer scale is measured in feet and the inner scale is measured in meters (see fig. 3-20).

Rangefinder focusing. The rangefinder has two windows. One, the viewfinder window, produces an overall view of the area to be photographed. The other, the rangefinder window, provides a small rectangular image positioned in the center of the viewfinder image. When the image is not properly focused, the rangefinder image appears offset from the image produced by the viewfinder. When the subject is in sharp focus, the images are superimposed, and appear to be a single image (see fig. 3-21).

Composing the photograph. The viewfinder is positioned slightly above and to the left of the lens. The difference between the viewfinder angle of coverage and the angle covered by the lens produces parallax. Parallax correction is provided automatically by a bright finder outline which is visible through the viewfinder eyepiece. The outline dimensions adjust to show the area covered by the 35mm, 50mm, and 90mm lenses. If you want to check the coverage to evaluate which lens provides the best coverage, there is

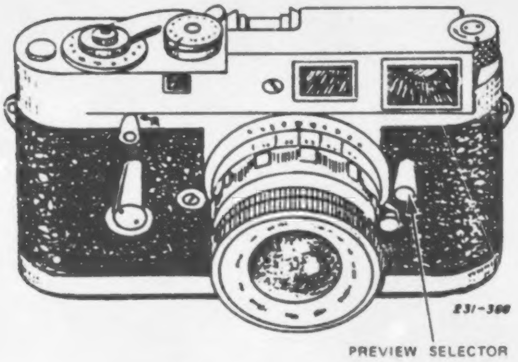


Figure 3-22. Preview selection.

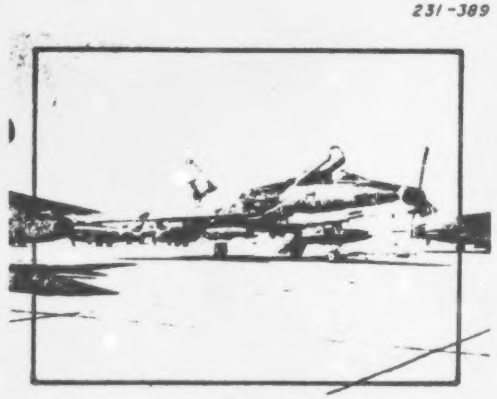


Figure 3-23. Subject coverage with 35mm lens.

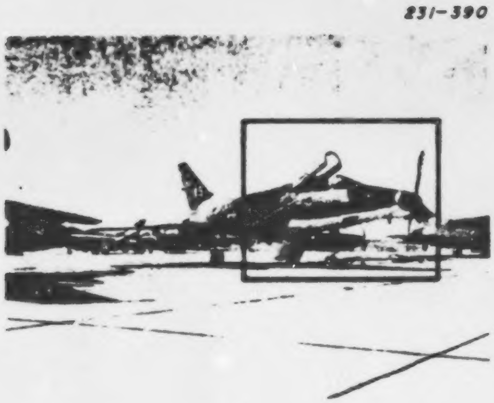


Figure 3-24. Subject coverage with 90mm lens.

a preview switch located on the front of the camera (see fig. 3-22).

With the preview selector in operation, outlines as in figures 3-23, 3-24, and 3-25 would show the total area covered from the same camera position. The wider coverage is provided by the 35mm lens, the smaller outline indicates the area covered by the 90mm lens, and the intermediate outline is the coverage provided by the 50mm lens.

Changing lenses. To remove the original lens, merely press on the catch located beside the bayonet lens mount, and rotate the lens barrel clockwise. When the red dot on the lens barrel is aligned with the catch, simply lift the lens from the camera body. To install the new lens, align the red dot on the lens barrel with the catch, insert the lens into the camera body, and turn the lens barrel in a clockwise manner until it stops with a click. Always provide a firm support for the camera body while changing lenses (see fig. 3-26).

PRECAUTION: Avoid changing lenses in strong light. If no other protection is available, shade the camera with your body. This helps to prevent fogging the film. Protect the interior of the camera from dust and other debris while the lens is removed. These materials can damage the camera's internal components. NEVER point the camera at the sun for more than a few seconds. The lens can focus the sun's rays on the focal plane shutter and burn a hole in it. Always keep your accessory lenses in their protective cases when not in use.

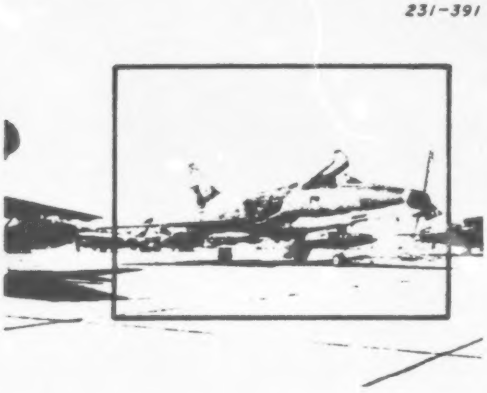


Figure 3-25. Subject coverage with 50mm lens.

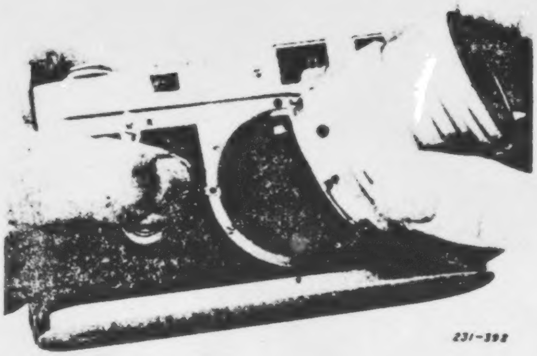


Figure 3-26. Lens catch.

Unloading the camera. Before you remove the exposed film from the camera, it must be rewound into the cassette. You begin this operation by setting the film transport reversing lever to the "R" position (see fig. 3-27). Then pull up the rewind knob and turn it in the direction of the arrow printed on the top of the knob.

Flash equipment. A variety of incandescent and electronic flash units are available for use with the "Leica" M-2. All short peak flash lamps are synchronized through the right-hand outlet which is identified by a flash bulb. All medium peak lamps, including focal plane, and electronic flash are synchronized through the left-hand outlet which is identified by a lightning bolt. (Because the "Leica" employs a focal plane shutter, electronic flash must not be used at shutter speeds higher than 1/50 second. This shutter speed is indicated on the shutter speed dial.) Protective plugs should be placed over the synch outlets to help prevent damage when they are not in use.

Cleaning the camera. Cleaning is an important step both before and after using the camera. Always check the finder windows and lens for dirt, dust, and fingerprints as the first step in preparing for an assignment. Remove loose dirt by blowing it gently, then wiping it off with a brush. Breathe on the lens, then use lens tissue or a soft, lintless

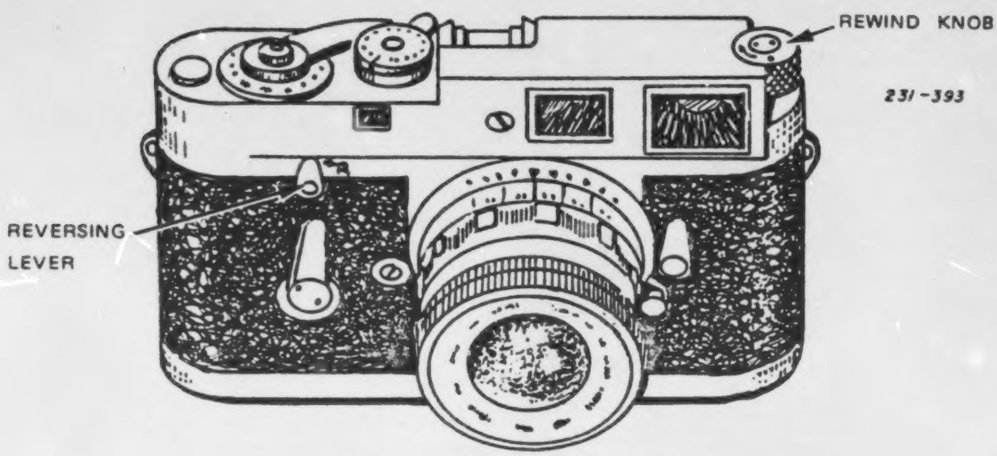


Figure 3-27. Rewinding the film.

cloth to wipe off any fingerprints or spots of moisture. Check the inside of the camera for dust, dirt, and other foreign material. Remove any foreign material with a soft brush. Do not touch the focal plane shutter with your fingers or cleaning materials. Dry the camera after it has been exposed to moisture such as rain or snow. Although it can be used in all weather, the camera may become damaged unless it is protected.

Exercise (224):

1. Complete the following statements on the operation of the "Leica" M-2.

   a. A rangefinder system, unlike a single lens reflex, can suffer from____________.
   b. "Leica" M-2 has optical frame lines for the____________, ____________, and ____________lenses.
   c. Roll film should be loaded in____________ ____________.
   d. The outer scale of the focusing ring is measured in____________.
   e. To remove a lens, the ____________ on the lens barrel is aligned with the catch.
   f. To rewind film you must set the ____________ lever in the ____________ position.
   g. When using electronic flash, you should not use a shutter speed above____________.
   h. The "Leica" has a ____________ ____________ shutter.
   i. A ____________ ____________ tells you how many shots you have taken.
   j. You should not use a shutter speed below ____________ without a tripod.
   k. Of the standard lenses that come with the M-2, the widest angle of coverage is provided by the ____________ lens.
   l. If you point your camera towards the sun you may ____________ a ____________ in the shutter.
   m. You should ____________ the camera after it has been exposed to rain and snow.
   n. A ____________ lens provides the narrowest angle of field of the three standard M-2 lenses.
   o. All short peak flash units are synchronized through the outlet marked by a ____________ ____________.

225. Complete statements about nomenclature and procedures of operation of the "Nikon" F camera.

The "Nikon" F. The "Nikon" F, as shown in figures 3-28 and 3-29, is a 35mm single lens reflex (SLR). The camera comes equipped with a 50mm f/1.4 automatic "Nikkor" lens. The lens is interchangeable through a bayonet mount system. The viewfinder system is also interchangeable and comes with a pentaprism and built-in, through-the-lens light meter. It is the large assortment of interchangeable lenses, finders, meters, and attachments that has made the "Nikon" system so useful.

Operation. We will review a few of the major operating and handling procedures of the "Nikon" F camera.

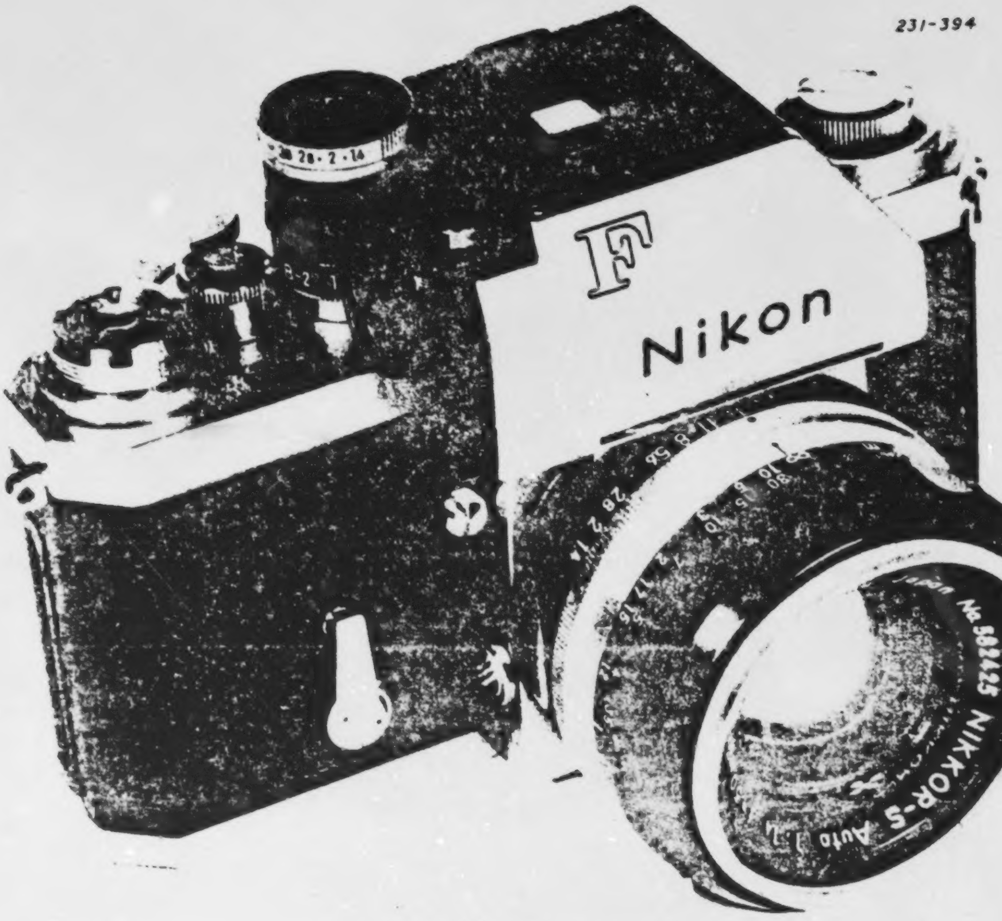


Figure 3-28. Front view of the Nikon-F camera.

Loading the camera. To open the camera, turn the lock on the camera bottom to the open position (see fig. 3-30). The camera back is now unlocked and may be removed by sliding it from the camera body. Now make sure the A-R ring (fig. 3-31) on the shutter speed dial is in the "A" (advance) position so that the shutter cocking mechanism is engaged. To load, place a film cassette into the camera and position it so that the top fits into the guide notch of the film rewind crank. Next, insert the end of the leader into the slot on the takeup spool so that the claw in the takeup slot engages the perforations of the film (fig. 3-30). Advance the takeup spool so that the film passes under the spool with the emulsion side facing outward (away from the spool core). Now replace the camera back and lock it. The camera is now loaded, but it is not yet ready for shooting.

You should now shoot off two frames so that the portion of the film exposed during loading is advanced. While you are doing this, make certain that the rewind knob rotates in the direction opposite to the arrow on the knob. This indicates that the film is correctly loaded and is properly advancing.

Focusing. To achieve sharp focus, turn the focusing ring on the lens to the right or left until the image in the finder is clear. To determine the exact distance from the camera to the subject on which you have focused, look at the figure on the distance scale, located on the lens barrel directly behind the focusing ring (see fig. 3-32).

Setting shutter speeds. All shutter speeds are set with click stops on the selector dial (fig. 3-33). The dial turns a full 360° in either direction. Align the desired speed with the white dot. At the "B" setting, the shutter

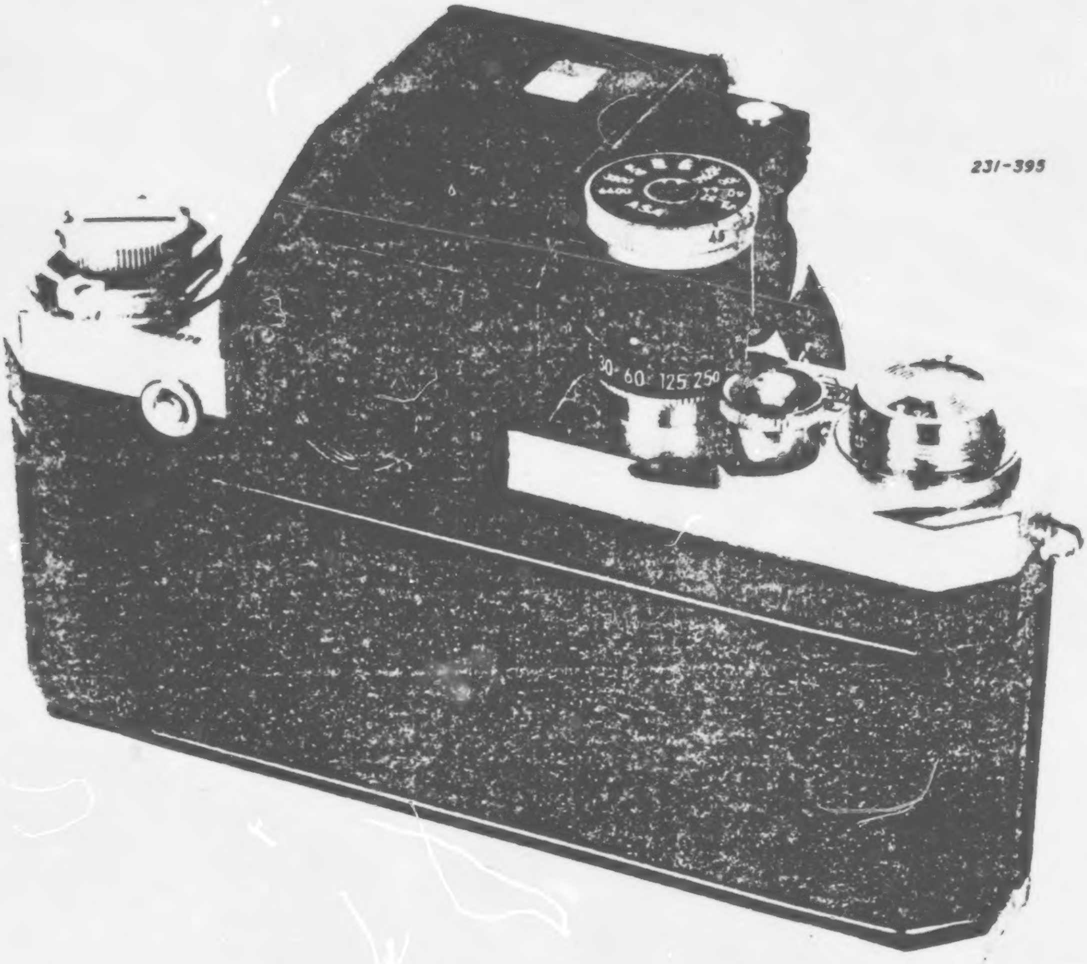


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Figure 3-29. Back view of the Nikon-F camera.

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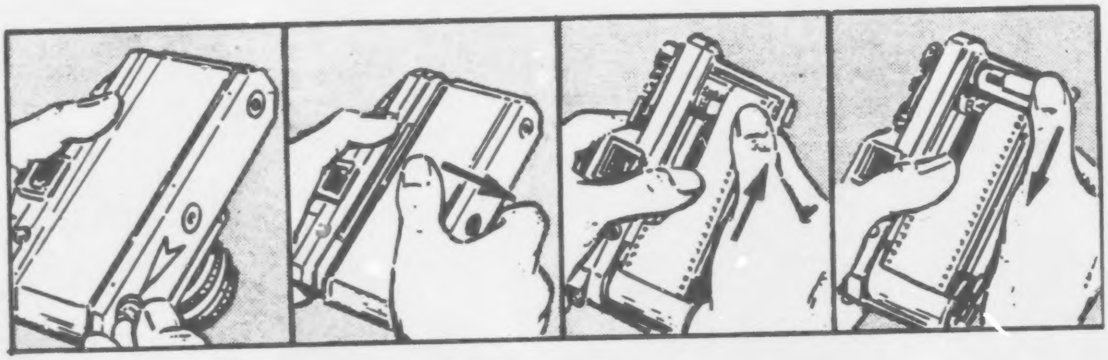

Figure 3-30. Camera lock.

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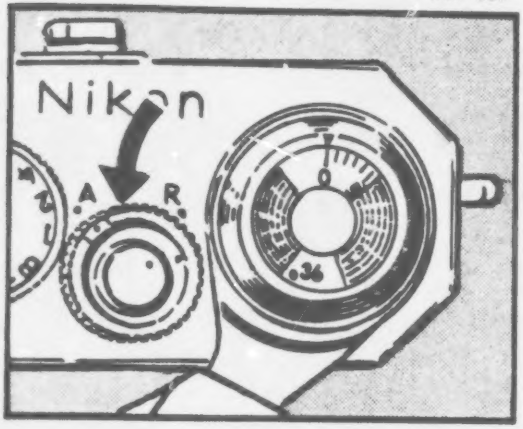

Figure 3-31. The A-R ring.

remains open as long as the shutter release is depressed. A cable release and a tripod should be used for shutter speeds slower than 1/30 second. At the "T" setting, the shutter remains open after it is tripped. It is closed by turning the shutter speed dial one click in either direction. An extremely sturdy support should be used for time exposure as there is likely to be camera movement when the speed dial is turned.

Aperture selection. The "Nikon" F camera is designed to use interchangeable Auto-"Nikkor" lenses. These lenses are so constructed that the diaphragm automatically closes down to the taking aperture when the shutter button is depressed. After exposure the diaphragm automatically returns to full aperture; consequently, the image in the finder is always seen as bright and clear with the exception of that instant when the shutter is released for exposure. To set the aperture, all you need to do is turn the aperture ring to the desired f/number. The f/number should be opposite the black indicator dot on the milled ring. Also, the diaphragm may be set for intermediate stops (half stops) when exposure is extremely critical.

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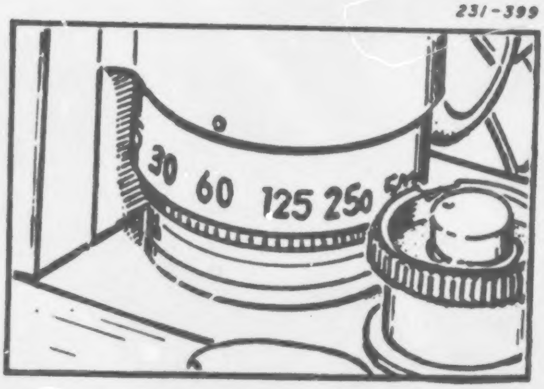

Figure 3-33. Shutter speed settings.

Film advance lever. A single motion of the film advance lever does three important things. In one movement (1) the film is advanced, (2) the shutter is cocked, and (3) the film exposure counter advances one frame. To operate the film advance lever, use the thumb of your right hand. Move the lever as far to the right as it will go. Remember, if the lever has not been advanced completely, the shutter button cannot be depressed, and the shutter will not operate.

Unloading the camera. As the last frame on the roll is reached, a strong resistance or reverse pull is felt in winding. Once this point is reached, you should make no further effort

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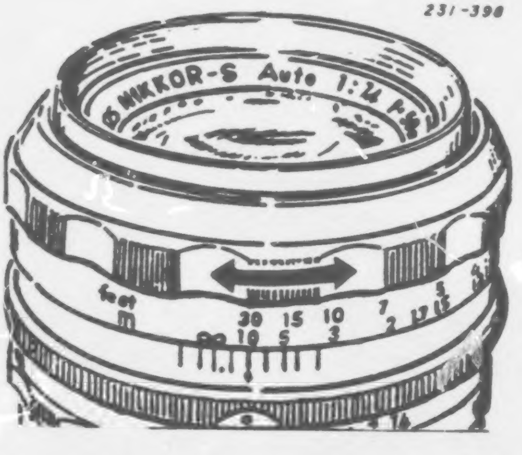

Figure 3-32. Focusing ring.

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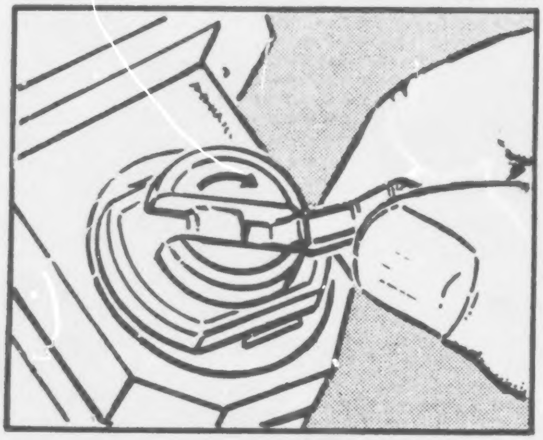


Figure 3-34. Rapid rewind crank.

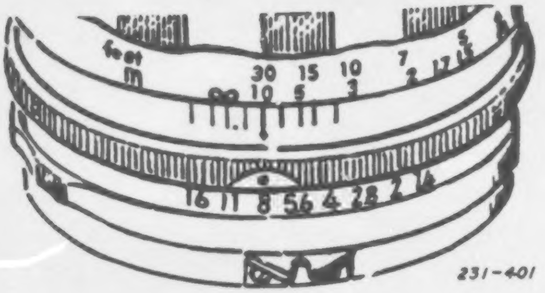


Figure 3-35. Depth-of-field scale.

to advance the film. All you need to do to rewind the film is turn the A-R ring to the "R" position, lift up and unfold the rapid rewind crank, and turn it in the direction of the arrow (see fig. 3-34). As the film is being rewound, you feel a slight pressure caused by the film being wound back into the cassette. Keep winding the film until this pressure stops. To insure that the film is being wound into the cassette, check the red dot on the shutter release button. It should revolve as you rewind. When the red dot stops its motion, all of the film has been wound into the cassette. Open the camera back and remove the film cassette.

Depth of field. "Nikkor" lenses have color-coded depth-of-field scales engraved on their lens barrel opposite the distance scale,

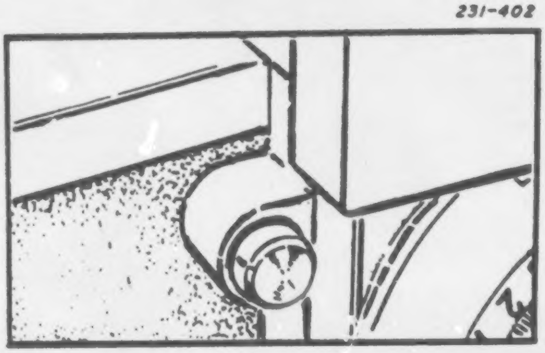
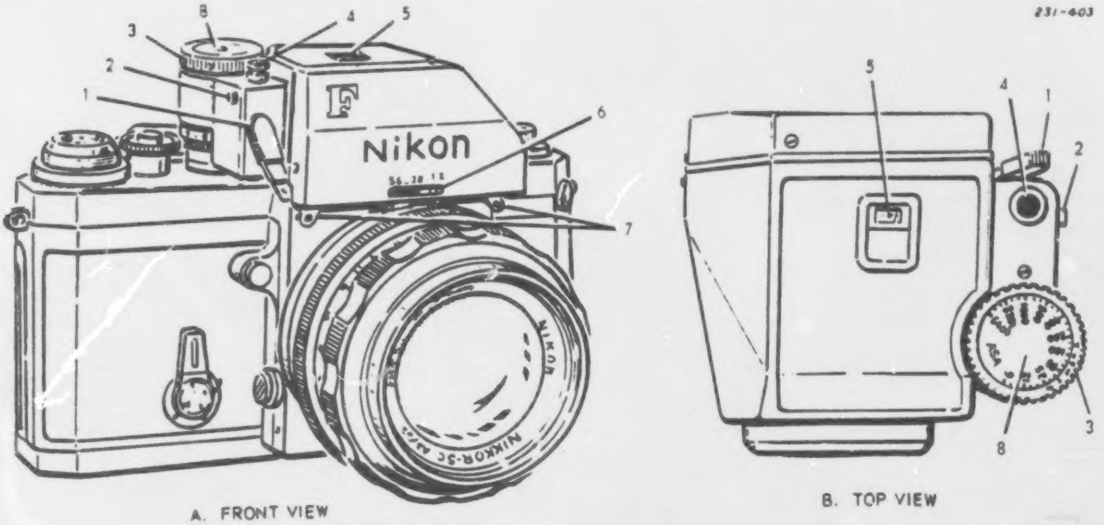


Figure 3-36. Depth-of-field preview control.

permitting easy viewing and reading of the depth of field for a selected aperture. Two sets of differently colored lines, one on either side of the black indicator line, represent different f/stops. The lines are color coded to match the color f-number figures on the aperture scale. As an example, when you are using the 50mm lens with the distance scale indicating 30 feet, the depth of field at f/8 is between 15 feet and infinity, as shown in figure 3-35. This indicates that the image should show a range of acceptable sharpness between 15 feet and infinity.

A depth of field preview button is located on the front of the camera (fig. 3-36). Press the button and the diaphragm closes down to



A. FRONT VIEW

B. TOP VIEW

1. FINDER LOCK LEVER
2. METER SWITCH-ON BUTTON
3. SHUTTER SPEED SELECTOR/ASA SCALE INDEX RING
4. METER SWITCH-OFF BUTTON
5. METER WINDOW
6. MAXIMUM APERTURE SCALE
7. CLAMPS FOR POSITIONING FINDER ON CAMERA
8. ASA FILM SPEED DIAL

Figure 3-37. The Nikon-F camera with Photomic FTN finder attached.

the preselected taking aperture. This allows you to "see" the depth of field at the selected aperture. Release the button and the diaphragm returns to its original position (fully open). The preview control is independent of the shutter release and cannot cause accidental exposure. A word of caution: Do not release the shutter while the depth of field preview control is being depressed. This causes the inside reflex mirror to remain in the UP, or "taking" position after the exposure. Make another exposure to return the mirror to the normal viewing position.

Using the "Nikon" Photomic FTN finder. The "Nikon" Photomic FTN finder incorporates a center-weighted Cds exposure meter, which couples to the camera's lens aperture diaphragm and shutter speed controls. It makes possible easy, accurate through-the-lens exposure measurement (see fig. 3-37).

The finder is powered by two 1.3-volt mercury batteries located in the battery chamber on the bottom of the finder. To check the batteries, press the meter switch-off button and observe the needle in the window on top of the finder. If the needle swings to the center circle or beyond, the batteries are still in good condition. To replace weak or worn-out batteries, unscrew the cap over the battery chamber and the batteries will drop out. Make sure that the positive (+) side faces out when new batteries are installed.

The Photomic takes advantage of the automatic diaphragm feature of "Nikkor" lenses to measure light with the lens wide open. Full aperture metering gives a bright, clear finder image for viewing and focusing and minimizes the effect of light entering the viewfinder from the rear. In order for the meter to measure exposure at full aperture with lenses of different maximum aperture, it must be coupled with the maximum aperture of the lens in use. This is done, each time the lens is attached or changed, by turning the aperture ring of the lens through its entire range.

With the lens mounted on the camera, twist the aperture ring counterclockwise, then clockwise as far as it will go. This meshes the coupling prong on the lens with the pin on the FTN finder and adjusts the meter for the maximum aperture of the lens. The adjustment can be verified by checking the maximum aperture scale on the front of the finder. The scale has a range from f/1.2 to f/5.6. For example, if the 50mm f/1.4 lens is mounted on the camera, the red index mark should appear between 1.2 and 2.8.

To set the film speed, lift and turn the milled ring around the ASA film speed dial, so that the red triangular index mark on the ring lines up with the number corresponding to the ASA rating of the film loaded in the camera. The film speed dial covers a range from ASA 6 to 6400. There are two dots between each pair of numerical marks for approximate intermediate settings, such as ASA 64, 80, 340, etc.

To operate the meter, switch on the meter circuit by pressing in the meter switch-on button located on the side of the finder. The meter switch-off button will then pop up and a red line around its circumference will be visible. This serves as a warning that the meter is on. To turn off the meter, depress the top button until the red line is no longer visible, and the meter switch-on button on the side of the finder pops out. Do not leave the meter on for long periods of time unnecessarily since the batteries are being drained as long as it is turned on.

The Photomic uses a center-weighted through-the-lens metering system that reads the light over the entire focusing screen but favors the central portion of the screen. This means that it is possible to get correct exposure in situations where an average reading of the entire screen would result in underexposure of the main subject—with strongly backlighted portraits, for example. Since measurement is always done at full aperture with Auto "Nikkor" lenses, the viewfinder image is bright and clear.

The correct exposure is found by centering the meter needle, either in the V-shaped notch which is visible in the viewfinder, or at the central mark located beneath the window on top of the finder. Turn either the shutter speed selector or lens aperture ring until the needle is centered. For fine adjustments of less than one f/stop, use the lens aperture ring, since it provides intermediate settings between the marked f/numbers. The shutter speed selector is not set for intermediate values. The shutter speed in use appears in the viewfinder, so the shutter speed can be adjusted while you are observing the exposure meter needle.

Under extremely low light conditions, the meter needle may center at the "B" setting on the shutter speed selector. If this occurs, the correct exposure time is 2 seconds. If the needle centers at "T," exposure time is 4 seconds. If the needle cannot be centered or still moves erratically after all possible aperture-shutter speed combinations have been tried, then the light is too bright or too dim for the meter.

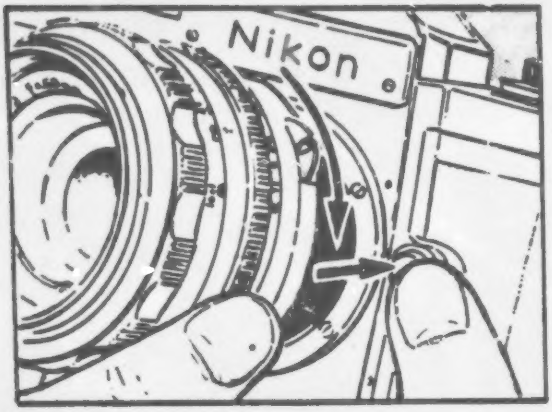


Figure 3-38. Lens release button.

The central part of the focusing screen should always be aimed at the main subject when you are centering the needle. Otherwise, unimportant bright or dark areas may influence the exposure reading. If an off-center composition is desired (your main subject is not in the center of the photo), first measure the light striking the main subject and set the aperture and shutter speed to center the needle. Then move the camera until the desired composition appears in the viewfinder.

To ensure accurate readings under any type of light condition, it is important for you to keep stray light out of the finder by using the finder eyecup.

When using bellows extensions, preset lenses or auto lenses without the coupling prong, the stop-down method of exposure measurement must be used. This means measuring exposure with the lens stopped down to the taking aperture. With the Photomic in this case, the meter coupling pin must first be pushed up into the finder so that the red index on the maximum aperture scale springs to f/5.6. Mount the lens or lens/accessory set up to the camera and switch on the meter in the usual way.

Changing lenses. To remove a lens from the camera's bayonet mount, support both components firmly as shown in figure 3-38. Depress the lock button, then turn the lens barrel clockwise to line up the black dots of the aperture indicator and on the camera body. Remove the lens carefully to avoid damage.

PRECAUTION: Do not expose the open camera to the sun. Protect the inside by using a body cap when no lens is installed. Cover the unattached lens with both front and rear caps and carry it in a case until it is installed.

Reinstall lenses by aligning the black dots, then pressing the lens in. Turn the lens counterclockwise until it clicks into position. Never use force during removal or installation of camera components.

Flash synchronization. Flash synchronization, always critical, becomes exceptionally important when you are using a focal plane shutter such as the "Nikon" F. The most obvious error is the use of shutter speeds which are shorter than the flash duration. This lack of synchronization results in only a portion of the film format being exposed to the light produced by the flash. Focal plane shutters pass light through slits to make the exposure. These slits vary in size from very narrow at fast shutter speeds to the full width of the focal plane at slow speeds. Flash duration must be at least as long as the minimum time required for the shutter aperture to cross the focal plane.

The "Nikon" F has a color coding feature which aids you in selecting the proper synchronization for each shutter speed/flash combination. All that is necessary, after removal of the Photomic finder, is for you to raise the selector ring on the center edge of the shutter speed dial, then rotate it. When the dot or letters in the selector window match the color of the selected shutter speed, proper synchronization has been set.

The guides in the selector window (fig. 3-39) are green or red dots, a white dot with a red F, or a white F and red X. Shutter speeds from B through 1/30 are marked in white on the shutter speed selector dial. 1/60 second is marked in red. Speeds of 1/125 second or faster are all in green.

Flash lamps are assigned to class FP (focal plane), M (medium peak), MF (miniature, fast

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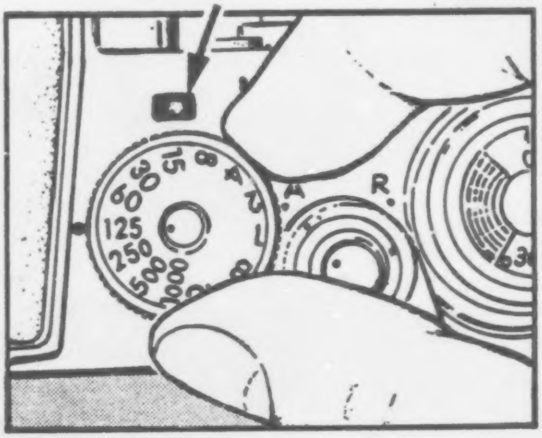

Figure 3-39. Synchronization coding.

peak), and X (electronic). The chart below describes the proper selection of shutter speeds and synchronization for each class of flash.

Class	Shutter Speeds		
	1/1000, 500, 250, 125,	60,	30, 15, 8, 4, 2, 1, B
FP	(Green Dot)	(Red Dot)	(White Dot and Red F)
M	(Green Dot)	(Red Dot)	(White Dot and Red F)
MF			(White Dot and Red F)
X		(White F and Red X)	

Cleaning. The exterior of the camera body should be wiped with a soft cloth after each use to remove moisture and dirt which may have been transferred from your hands. Although there is little chance of damage to the camera from brief exposure to damp weather, it should be dried as soon as possible after it's used in rain or snow. Use a soft brush or air bulb to remove dust and dirt particles from the inner camera. Wipe the film pressure plate clean. Insure that no bristles, lint, or film particles remain inside the camera after cleaning.

DO NOT exert any force against the shutter curtain. It is made from extremely thin titanium foils and may be damaged easily.

DO NOT apply excessive pressure against the mirror.

Clean the lens and mirror first with the air syringe or brush, then, if necessary, with lens tissue. With proper handling, you should never need to wipe spots from the reflex mirror. Clean spots from the lens surfaces with lens cleaning fluid and lens tissue. The interior of the camera should be protected from moisture at all times. Be very careful not to scratch the viewfinder screen during cleaning. Its plastic material is damaged easily. Never attempt to disassemble the lens unit. This is a job for highly qualified camera maintenance personnel, as is any oiling which may be necessary.

Exercise (225):

1. Complete the following statements on the operation of the Nikon F.
   a. The Nikon F features a __________ lens mount.
   b. When you are taking pictures, the A-R ring should be in the __________ position.
   c. In the __________ position, the shutter remains open as long as the shutter release is depressed.
   d. Due to lenses with __________ __________ the image in the finder remains bright except at the exact moment of picture taking.
   e. When you want to rewind your film, the A-R ring is in the __________ position.
   f. By engaging the depth of field preview button, the diaphragm closes down to the __________ __________.
   g. The FTN finder is powered by two __________ volt mercury batteries.
   h. The FTN finder incorporates a __________-__________ cds meter.
   i. To close the shutter in the __________ position, you must turn the __________ __________ dial.
   j. Correct exposure is indicated when the meter needle centers in the __________ shaped notch.
   k. If the meter needle centers on "B" the exposure time is __________ __________.
   l. Using a shutter speed __________ than the flash duration results in image cutoff.
   m. When using FP bulbs and a shutter speed of 1/500, you should use the __________ __________ setting.
   n. The shutter curtain is made of __________ and is easily damaged.

3-3. Press-Type Cameras

The type of camera used to accomplish the majority of the photographic assignments at any photo lab depends primarily on the lab's mission. However, most photo labs depend heavily on the press-type camera. The relatively large negative format, combined with portability and versatility, makes it the workhorse of the Air Force.

The press-type camera is used for hand-held operation under a wide variety of conditions which require a maximum speed of operation. Although the design of the camera is such

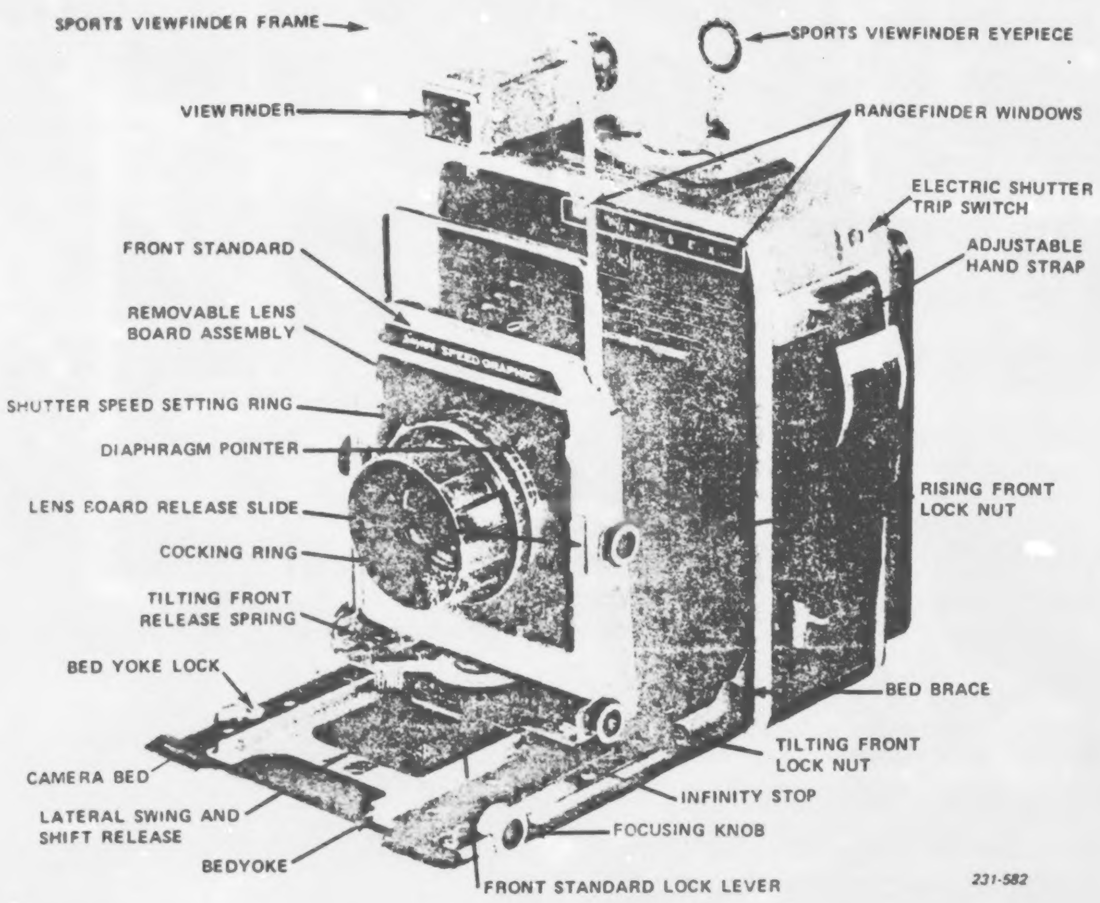

Figure 3-40. Graflex Super Speed Graphic camera (front view).

that it works ideally for eye-level operation while held in your hands, you can also use it on the tripod in much the same manner as the view camera is used. The press camera, however, does not have all of the many adjustments of the view camera which are necessary for full perspective control.

The traditional type press camera for the Air Force has been the 4 x 5 graphic type. In this section, we will discuss the operation of the Super Speed Graphic, which is representative of this type of camera.

226. Distinguish between accurate and inaccurate statements concerning the description, operation, and use of the Super Speed Graphic.

The Super Speed Graphic Camera. The all-metal Super Speed Graphic offers a number of advantages over earlier models of similar cameras. Some of these advantages include reduced weight and size, a greater range of shutter speeds (1/2 second to 1/1000 of a second), provision for coupling the rangefinder to lenses of different focal lengths, electrically-operated shutter, and built-in flash computer.

As we take a closer look at the features of the Super Speed, refer to figures 3-40 and 3-41 and identify the various components as follows:

a. The sports viewfinder eyepiece is mounted on the back of the camera. This eyepiece positions your eye for composing the picture through the sports viewfinder frame attached to the front standard. To aid you in correcting parallax so that the lens sees

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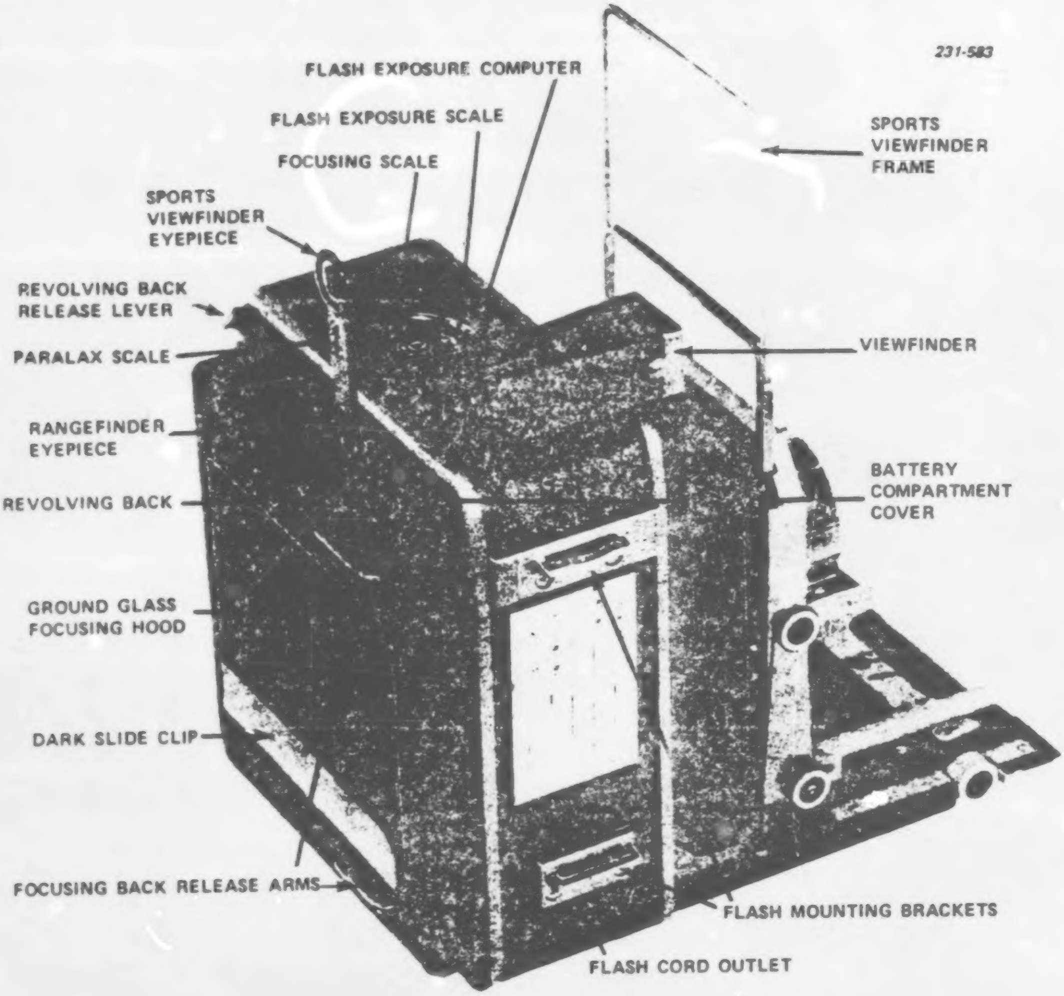

Figure 3-41. Graflex Super Speed Graphic camera (rear view).

what your eye sees, the eyepiece is calibrated for infinity, 15, 8, and 5 feet.

b. The battery compartment holds two 11½-volt batteries to supply the electrical power used to trip the shutter.

c. The rangefinder is an integral part of the camera body and uses interchangeable cams. With the proper cam in position, the rangefinder and focusing scale pointer indicate the true focus of the lens being used.

d. When the electric shutter tripping button on the camera is pressed, the heavy duty solenoid (electromagnet) concealed in the frame beneath the lens board depresses the mechanical link built into the lens board assembly and trips the shutter.

e. The focusing scale pointer on top of the camera is controlled by the rangefinder cam. No setting or other adjustment is necessary after the correct cam has been inserted into the rangefinder.

f. An adjustable flash exposure scale combined with the focusing scale on top of the camera automatically indicates the correct diaphragm opening for normal flash exposures.

g. An accessory optical viewfinder is mounted on top of the camera. It provides another method of evaluating what the camera lens sees. Note that this eyepiece is also adjustable for parallax correction.

h. A ground glass at the rear of the camera is used as an exact image viewing device when such exactness is desirable.

Opening the camera. To open the camera you should follow these procedures.

(1) Pull up either or both of the knurled focusing knobs on the face of the bed. This releases the bed so it can be pulled down.

(2) Pull down the bed until it locks in the horizontal position.

(3) Rack the track back on its stop.

(4) Swing the front standard lock lever out straight.

(5) Pull the front standard outward on the track to the infinity stops. These stops are hinged and when being used should be in an upright position.

(6) Relock the front standard.

(7) Erect the sports viewfinder frame by pinching inward against the side of the coiled wire frame while simultaneously pulling upward as far as possible.

(8) Swing the sports viewfinder eyepiece to an upright position and adjust it to the correct distance at which you are going to shoot.

Camera operation. The best way to learn the operation of the Super Speed is by placing the camera on a tripod for secure support. Then begin by aiming the camera. Pick out an object about 15 feet away. Use the sports viewfinder to align and compose your picture.

The sports finder is an integral part of the camera and is often used when speed is essential (such as in shooting sports events). Find the parallax scale. Note that the scale is graduated and movable. Since your target is 15 feet away, you must set the scale at 15. This aligns the eyepiece with the lens and thus corrects for parallax at this one distance.

The next step is to focus the camera. You can do this by any one of three methods: (1) rangefinder, (2) ground glass, or (3) focusing scale. Let's take the rangefinder first. Look into the rangefinder eyepiece located on the upper rear edge of the camera. As you look through the eyepiece, rack the front standard forward until the subject, as seen in the center of the field, exactly coincides with the large stationary image of the subject. The image falling on the focal plane (the area where your film is located in the camera) will then be in sharp focus.

Ground glass focusing is recommended for all critical photography, including copying, since it allows you to check sharpness of focus, depth of field, aim, composition, and the shape of the image exactly as they will be recorded on the film. To use the ground glass, all you have to do is press the latch down to open the focusing hood. The ground glass is located directly behind the hood. To focus, look at the ground glass and move the focusing knobs back and forth until you see a clear image of your subject. You have now focused the camera for that particular distance.

The focusing scale is another method you can use to focus the camera. The scale is located on top of the camera and works directly with the rangefinder. As you rotate the focusing knobs, a needle or pointer moves along a calibrated scale. This scale is often used to focus the camera to some estimated distance. For example, if you estimate a camera-subject distance to be 10 feet, set the scale to this distance. If you guessed right, the subject is in focus.

The next thing to do is to decide if you should use a horizontal or a vertical format. To evaluate which format to use, apply the following rules:

- If the subject is taller than it is wide, shoot vertically.
- If the subject is wider than it is tall, shoot horizontally.

Depending on the chosen format, you may have to rotate the back. Locate the revolving back release lever. To operate, push down on the lever with your left hand. With your right hand, rotate the back to the position desired. If you have chosen the vertical format, be sure to have the film receiver of the revolving back facing upward. You can easily identify this by the location of the two metal tabs on the upper, outer edges of the revolving back.

Now let's look at the shutter. We cover the operation of the "Graflex" 1000 shutter because it differs from the operation of small camera shutters. All controls are visible from the top of the shutter and can be quickly set. No special sequence of operation need be followed when you use the "Graflex" 1000 shutter. All directions given (left and right) are from the front of the shutter.

To cock the shutter you must turn the large ribbed ring, which also serves as a lens shade, clockwise as far as possible. (The blades will not accidentally open in the event that the cocking ring is turned only part way and then allowed to turn backward to the original position.)

To trip the shutter, you may use any one of the following methods: (1) press the red release button at the top left side of the camera body; (2) press the red switch on the back of the flash battery case; (3) use a cable release screwed to the taped boss just above the shutter release lever; or (4) press the release lever at the side of the shutter. The shutter cannot be tripped unless it is fully cocked.

To set the diaphragm, move the lever at the top right of the shutter to the desired number (f/stop) on the diaphragm scale.

To set the shutter speed (either before or after cocking), turn the knurled outer ring until the red dot on the raised knurl is opposite the desired speed on the shutter speed scale. In making bulb and time exposures, use a locking-type cable release and set the shutter speed ring at "B."

For a ground glass check of focus and composition, move the control lever at the lower left corner of the lens board (below the shutter release lever) clockwise to the "O" position. The shutter blades and the diaphragm leaves will open fully. To close, move the lever back to "C."

If you wish to focus while you are adjusting the diaphragm, move the knurled shutter speed ring to "O" (next to "B"). Cock the shutter and trip. The shutter opens fully while the diaphragm remains at a preselected setting. You may then adjust the diaphragm from this position. This procedure is useful to determine the diaphragm opening for proper depth of field when you are focusing with the ground glass. To close the shutter, move the shutter speed ring away from "O" to any desired setting and recock the shutter.

All you have to do now is load the camera. To do this, fit the 4" x 5" cut film holder to the camera by sliding it under the focusing back as far as possible. The darkslide, when withdrawn, can be held in the darkslide clip. The darkslide clip is the metal strip found on the bottom edge of the focusing hood.

Closing the camera. When the camera is being closed, the following procedures apply:

(1) Close the sports viewfinder frame. Press evenly on both sides or tap the top member with the flat of the hand.

(2) Swing down the sports viewfinder eyepiece at the back of the camera.

(3) If the front standard movements (rising front, lateral shift, or lens board tilt) have been used, return them to normal as follows:

- Drop the lens board to the lowest position and lock.
- Tilt the lens board back to its normal, vertical position and lock it.
- Bring the front standard to a neutral position.

(4) Rack the bed yoke back to the limit of its movement.

(5) Unlock the front standard and push it back into the camera body and lock it.

(6) Press down on the bed braces to release the locking mechanism and close the bed.

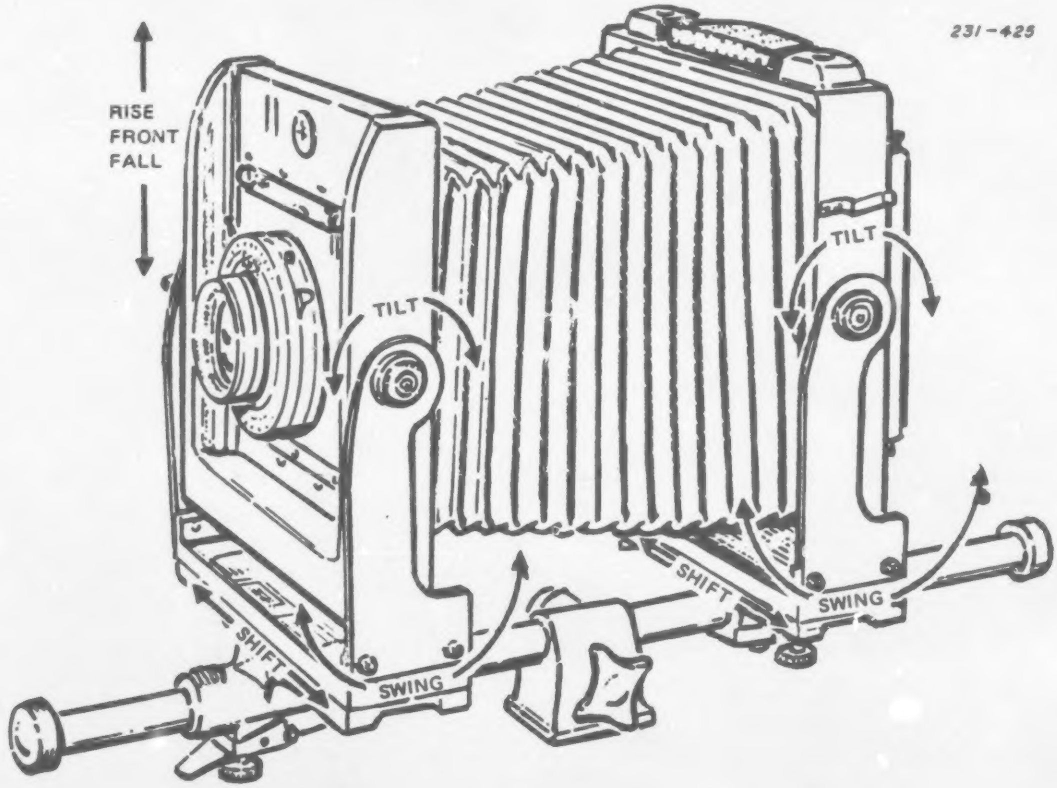

Figure 3-42. View camera (front and side view).

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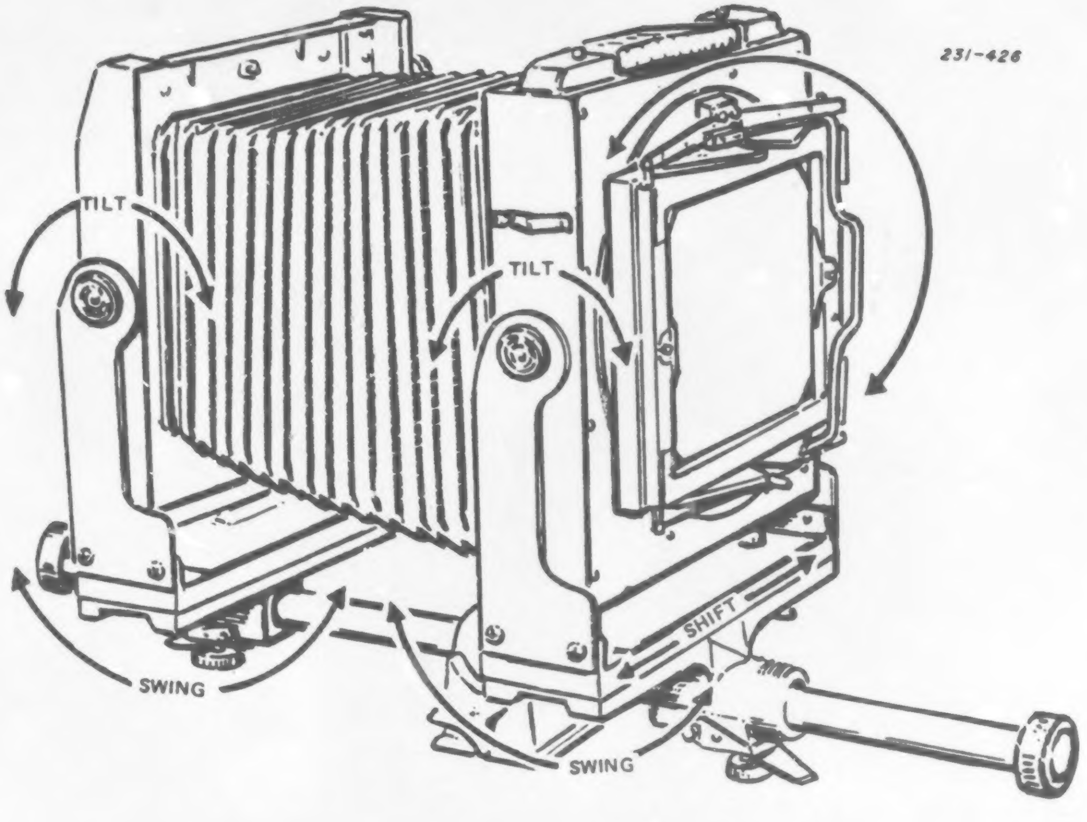

Figure 3-43. View camera (side and back view).

Exercise (226):

1. Identify each of the following statements concerning the "Super Speed Graphic" as true or false.
   a. The sports viewfinder eyepiece is calibrated to correct for parallax.
   b. The battery compartment contains two 10-volt batteries.
   c. Ground glass focusing is the most accurate focusing method.
   d. The "Super Speed Graphic" has four methods of focusing.
   e. Rangefinder focusing is ideal for copy work.
   f. An optical viewfinder is used to evaluate lens coverage.
   g. The "Super Speed" has a revolving back for either vertical or horizontal composition.
   h. The sports viewfinder provides accurate focusing for sports and other action events.
   i. The cocking ring on the "Graflex" 1000 shutter also acts as a lens shade.
   j. The control lever should be in the "0" position for ground glass focusing.

3-4. View Cameras

The view camera provides all of the functions necessary for precise rendering of the subject. Through the use of the camera's rising and falling front, swings, tilts, and shifts, the photographer has complete control over the composition of the subject. The view camera is ideal for architectural, engineering, and portrait photography. The camera has the capability for bellows extension to at least twice the focal length of the lens, making it suitable for copy work and photographing small objects. Most Air Force view cameras use 4- x 5-inch or 8- x 10-inch sheet film. By mastering the view camera, you add a versatile tool to meet your photographic assignments.

227. Briefly explain the function of swings, tilts, slides, falls, and rises as used on view cameras.

View Camera Movements. A first glance of figures 3-42 and 3-43 may make the view camera appear complicated because of its

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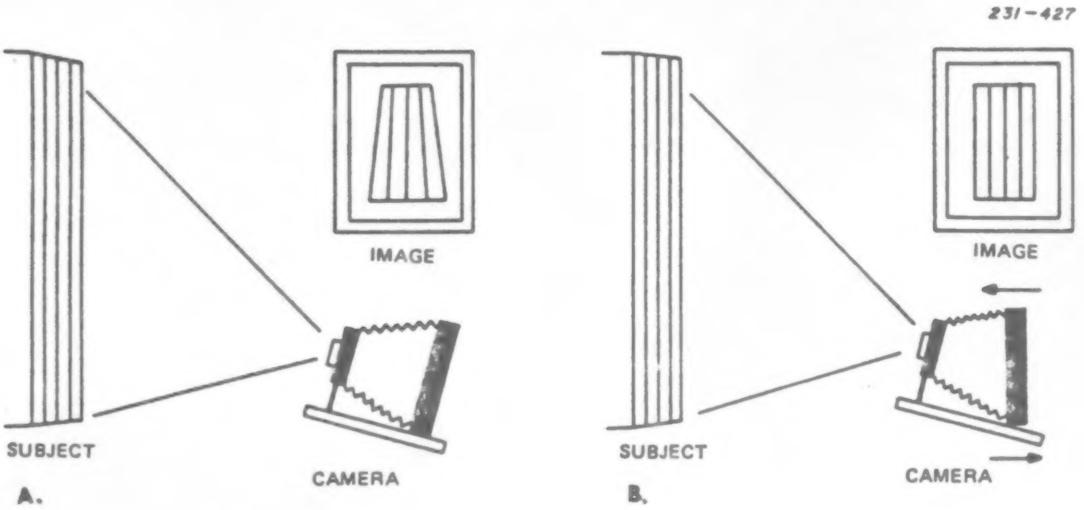

Figure 3-44. Vertical tilt.

many movable parts. But once the principles of its operation are understood, it becomes the ideal camera for subjects requiring correction of perspective and increase of depth of field.

The three basic rules that, once memorized, make the view camera less mysterious to use are as follows:

1. The rising, falling, and sliding movements are used to control the position of the image on the ground glass (film plane).
2. The vertical tilt and horizontal swing of

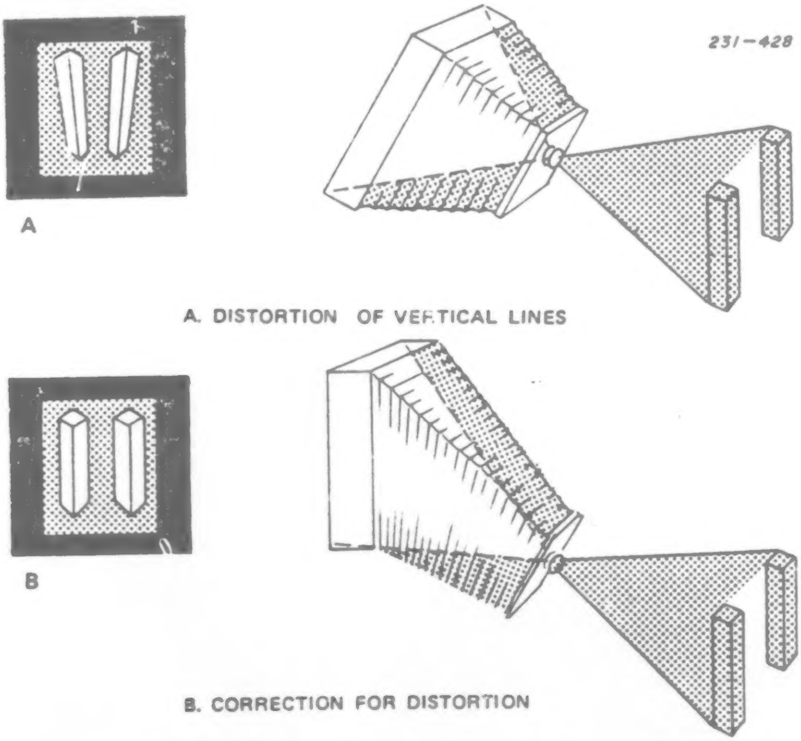

Figure 3-45. Correction for vertical distortion.

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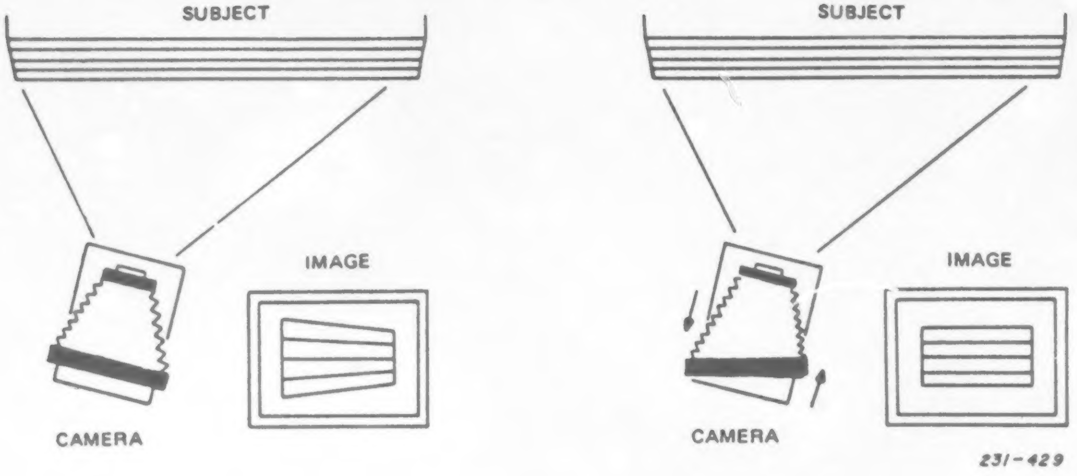

Figure 3-46. Using horizontal swing adjustment to correct horizontal converging lines.

the camera back are used to control the shape of the image on the ground glass.

3. The vertical tilt and horizontal swing of the camera front are used to control the focus of the image on the ground glass.

Combinations of the various movements may be made, but the purpose of each should be kept in mind. In describing the operation of the view camera, features that correct distortion are described first.

Vertical tilt back. The vertical tilt back is used to correct distortion or perspective in the vertical plane. Tilting the camera up results in a convergence (in the ground glass image) of the vertical lines of the subject (see fig. 3-44,A). This is quite apparent when you are photographing a tall building. If no correction is used, the building looks smaller at the top. Since the top of the building appears on the bottom of the ground glass, loosen the locking knob of the vertical tilt back and pull the bottom of the back to the rear. This increases the size of the top of the building while decreasing the opposite end (see fig. 3-44,B). Maximum correction is achieved when the film plane is parallel to the subject.

When no vertical corrections are used, tilting the camera down results in a divergence (on the ground glass image) of the vertical lines of the subject (see fig. 3-45,A). In this case, the top of the back is pulled backward to make the correction (see fig. 3-45,B). In both cases the vertical distortion has been corrected; however, the image may not be in sharp focus all over because the vertical tilt front was not used.

Horizontal swing back. The horizontal swing back is used to correct distortion or perspective in the horizontal plane. In photographing subjects from an angle, the horizontal lines have the appearance of excessive convergence. To correct for this distortion, the camera back is swung horizontally to a position more nearly parallel to the horizontal lines of the subject. Figure

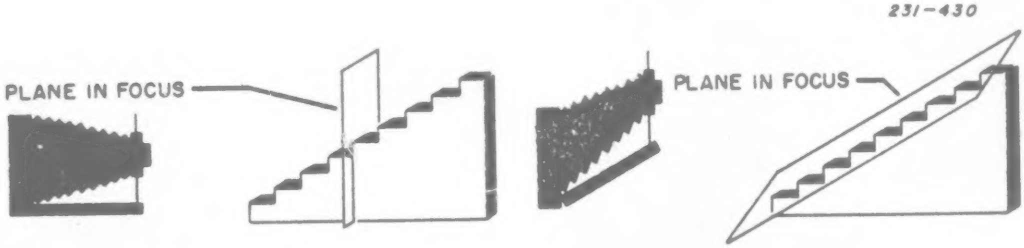

Figure 3-47. Vertical tilt front.

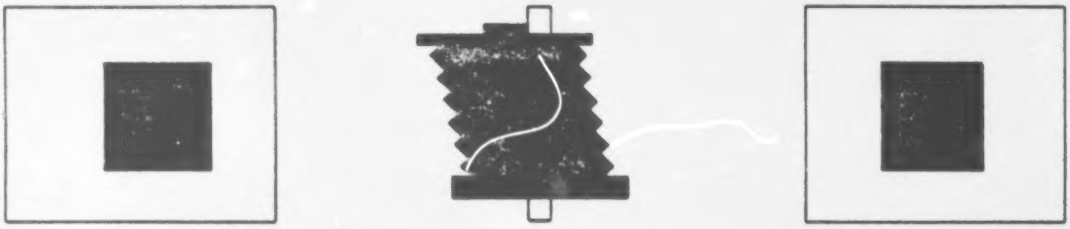

Figure 3-48. Using sliding front to center subject.

3-46 illustrates how horizontal distortion from the same point of view can be corrected or modified by using the swing back.

Vertical tilt front. The vertical tilt front is used to focus and increase the depth of field when the vertical tilt back is set off center (see fig. 3-47). When the vertical tilt back is tilted away from center, the film plane is not parallel to the image produced by the lens. To use the vertical tilt front, loosen the support arm knob and tilt the lens board forward or backward to bring the subject into focus on the ground glass; then retighten the knob. This does not affect the shape of the image, but it changes its position on the ground glass. By alternately moving the back and front tilts, the desired results can be obtained. This displacement can also be compensated for by using the rising-falling front.

Horizontal swing front. The horizontal swing front is used to focus and increase the depth of field when the horizontal swing back is set off center, as in the case of the vertical tilt back. When the horizontal swing back is placed off center, the film is not in the same plane as the image produced by the lens. To use the horizontal swing front, loosen the carriage lock knob and swing the front until the subject is in overall focus on the ground glass. As we stated when discussing the vertical tilt front, it is necessary to compensate for image displacement.

Sliding front and back. The sliding front is used to center an object on the ground glass when the object is not directly in front of the lens. If, after setting the camera on a tripod (when photographing a small part or making a copy of a photograph), you find that the subject is not centered, use the sliding front to center the subject instead of moving the tripod (see fig. 3-48).

If enough correction cannot be obtained with the front standard alone, it is possible to increase the correction by shifting the back frame in the opposite direction, as shown in figure 3-49. If this still does not give enough correction, maximum correction may be obtained by loosening the pan head and swinging the camera body in the same direction as the front standard and employing the horizontal swing of the front and back (see fig. 3-49). The sliding front and back can also be used to compensate for image displacement encountered when correcting distortion.

Rising-and-falling front. As the sliding front was used to center the subject horizontally on the ground glass, the rising-and-falling front is used to center the subject vertically on the ground glass, as shown in figure 3-50. To operate, press the rising front lock knob in, then turn it in to position the lens. When enough correction has been obtained, release the knob to lock the front in position. If

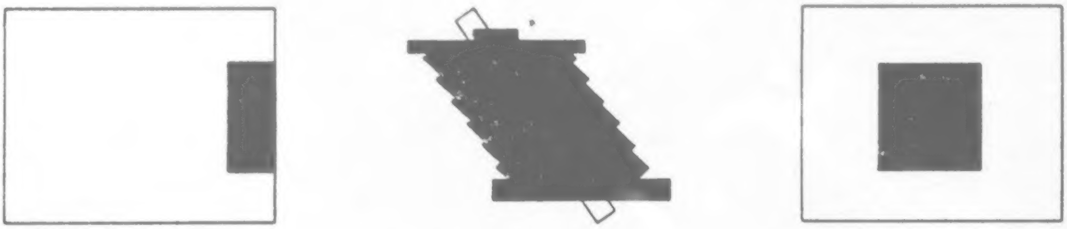

Figure 3-49. Sliding front and back combined with swing.

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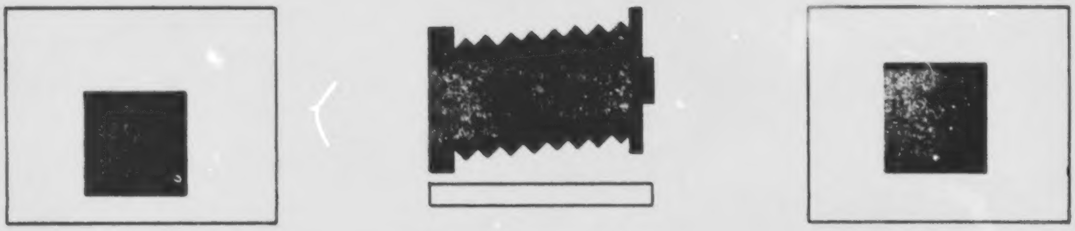


Figure 3-50. Centering the subject by using rising front.

enough correction cannot be obtained by this method, additional correction can be obtained by swinging the camera bed up or down, while using the tilting front and back to keep the subject in the same plane (see fig. 3-51). The rising-falling front can also be used to compensate for image displacement encountered when you are correcting for vertical distortion.

CAUTION: Be sure to check each corner of the ground glass to insure that the entire image is still within the usable circle of illumination when you are making these adjustments.

Depth of field control. In order to get greater depth of field than can be obtained by stopping down the lens aperture, the vertical tilt and horizontal swing front is employed. Stopping down the lens to very small apertures, while increasing the depth of field, results in a loss of definition. Use of the front tilt and swing permits obtaining depth of field in vertical, horizontal, or intermediate planes with the lens diaphragm at a larger aperture. This allows faster shutter speeds when necessary. The vertical tilt and horizontal swing of the lens board is even more valuable in closeup photography.

Figure 3-52 shows control of depth of field through the use of the front tilt and swing. The lens has been tilted slightly toward the plane desired to be in sharp focus. The front is raised to bring the image into proper place on the ground glass. The adjustments for increasing the depth of field are very critical and must be watched closely on the ground glass.

The tilt back can be employed to obtain greater depth of field where two principal subjects are on different planes (see fig. 3-52).

By tilting the back of the camera (line CD to position ED), the lack of parallelism between the back and subject plane is increased. This action increases the apparent depth of field. When the back of the camera is tilted at an angle to the plane that passes through the two points of focus that are at different distances from the camera (line AB), the effective depth of field is increased.

CAUTION: On some shots this action is apt to increase the convergence of parallel lines and produce badly distorted images.

Exercise (227):

1. Briefly explain the function of each of the following view camera movements:
   a. Horizontal swing back.

   b. Horizontal swing front.

   c. Vertical tilt front.

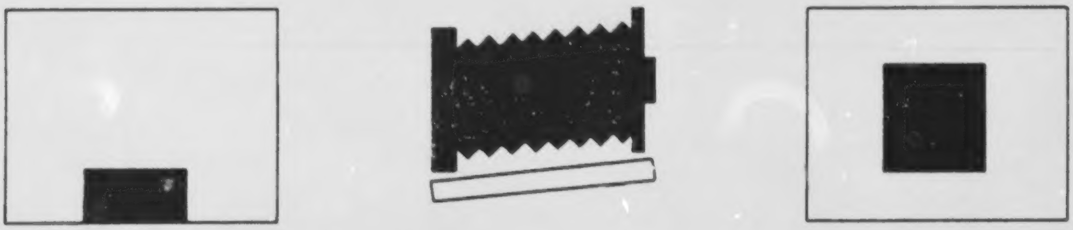


Figure 3-51. Combined rise and tilt adjustment.

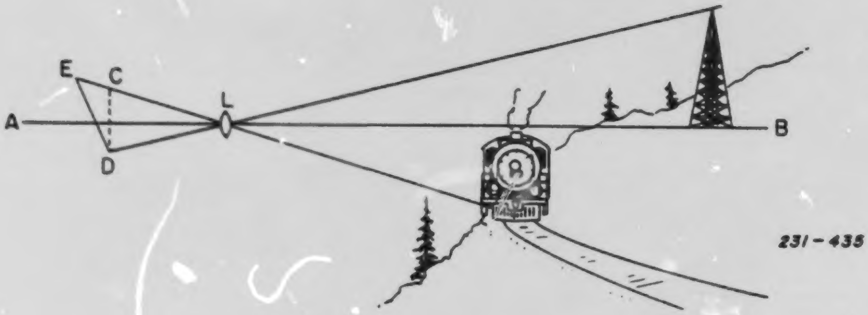


Figure 3-52. Increasing depth-of-field with the back.

d. Vertical tilt back.

e. Sliding front.

f. Sliding back.

g. Falling front.

h. Rising front.

228. Complete statements about the description and operation of the "Calumet" 4 x 5 view camera.

4 x 5 "Calumet" View Camera. To understand view camera operation better, we now discuss the operation of the "Calumet" view camera, commonly found in the Air Force.

The "Calumet" is available in two types. One type has a 16-inch bellows extension capability; the other model has a 22-inch bellows extension. Features common to both models include:

a. Aluminum frame.

b. Vertical tilts (30°) to correct distortion or increase depth of focus in the vertical plane.

c. Spirit levels, mounted on top of the camera back, which indicate when the camera is level.

d. Horizontal swings (12°) on both front and back for horizontal distortion correction and for increasing depth of focus.

e. Rising-falling front with a 3-inch rise or 1-inch fall. (Image placement may be controlled on a vertical axis by the rising and falling front.)

f. Horizontal slide for lateral (side-to-side) image placement.

g. Revolving back, enabling the camera to be used not only in a vertical or horizontal position but at any point throughout a complete circle.

h. Interchangeable metal lens boards.

i. Quick-release ground-glass frame having a big handle which, when pulled down, relieves tension and opens the back to receive a film holder.

j. Capability to accept standard film holders, plate holders, film pack adapters, "Polaroid" film holders, and roll film adaptors.

Camera Operation. All view cameras are intended for normal operation on a tripod. Although this camera is comparatively light in weight, it still requires a sturdy support. Always check the stability of the tripod before installing the camera.

To remove the camera from its case, grasp the tripod block and raise it straight up from the camera compartment. (The camera is carried upside down in its case.) Grasp the handle strap on top of the camera body as soon as it clears the case. Support the camera by its handle until you have guided the tripod block onto the tripod head and locked the two together with the screw.

Study figure 3-53 for the location of the major features of the camera. Although most cameras operate on the same basic principles, you must know the procedures for each specific type to avoid possible damage. This knowledge can prevent accidental breakage

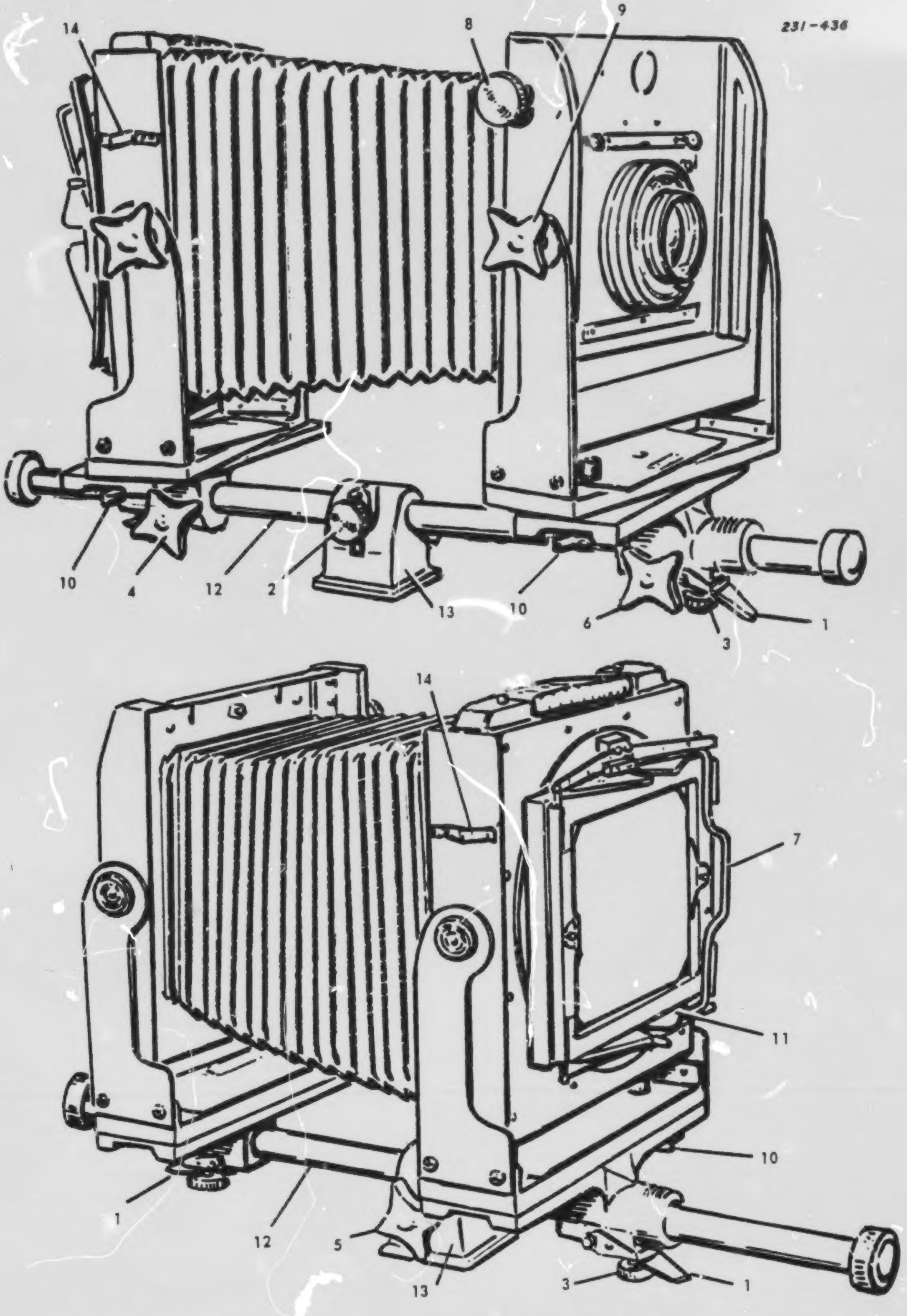


Figure 3-53. Components of the 4 x 5 "Calumet" view camera.

through attempts to force operation of locked components or from failure to lock components in place.

The following are the basic components of the "Calumet" as shown in figure 3-53.

1. Release levers for the front and rear standards—permit rapid focusing.

2. Center locking screw—locks camera rail in tripod block.

3. Back locking screw, front locking screw—lock standards in position after focusing.

4. Back focusing knob—positions rear standard.

5. Rail knob—positions camera in relation to tripod.

6. Front focusing knob—positions front standard.

7. Ground glass frame release handle—for insertion and removal of holders.

8. Rising front adjustment knob—locks rising/falling front in desired position.

9. Vertical tilt knob—releases front and locks in desired position.

10. Horizontal swing knob—releases for swing or horizontal shift, relocks in desired position.

11. Clamping lever—locks revolving back in desired position.

12. Monorail camera bed—supports front and rear standards.

13. Tripod block—for attachment of camera to tripod.

14. Focusing cloth clips—hold focusing cloth on camera during operation.

Ground glass focusing. After you have positioned the camera to give the desired view of the scene, open the lens aperture. To move the front and back standards on the monorail to achieve sharp focus, do the following:

- Loosen the front and back locking screws. For rapid focusing, lift the focusing release lever, then slide the standard along the rail.
- Turn the focusing knobs to position the front and/or rear standards for focusing. Initial focusing should be done with the front focusing knob.

Critical adjustment of image size. After you have positioned the camera to give the approximate image size desired, slight changes in camera position may be necessary. You can adjust the camera position relative to the tripod block by moving the monorail within the tripod block.

To move the camera forward or backward on the tripod, do the following:

- Loosen the center locking screw.
- Reposition the camera as necessary with the rail knob.

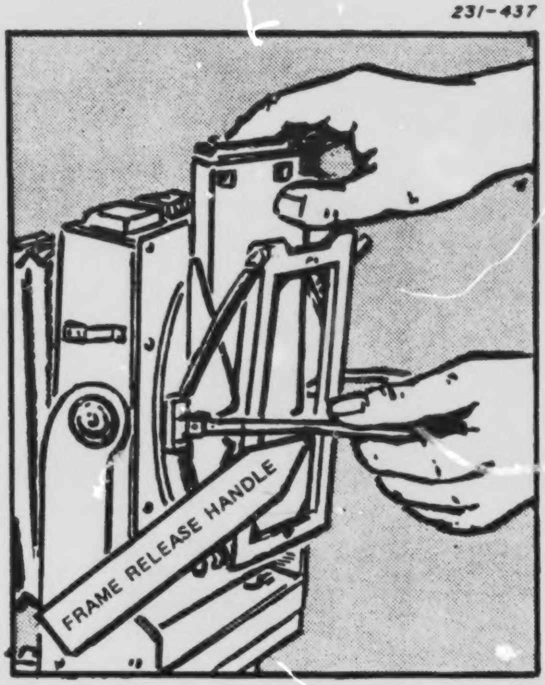


Figure 3-54. Loading the "Calumet."

- Relock the rail with the center locking screw.
- Adjust the focus.

Loading the camera. Standard film holders are normally used with the "Calumet" view camera, and you can insert or remove the holders without disturbing the camera position (see fig. 3-54).

To load the camera, do the following:

- Pull out the frame release handle until it reaches a right angle to the back and the rollers hold it in the depressions.
- Insert the film holder, insuring that it rests on the stops beneath the focal plane.
- Release the handle, then allow it to return gently to the closed position. (Close the shutter before removing the holder's dark slide.)

Corrective adjustments. As with any view camera, the "Calumet" has adjustable positioning of components for correct focus, composition, and distortion control. By making appropriate changes in lens and focal plane positions, you can use this camera to produce sharply focused images which would be impossible with other equipment. Image placement on the film can be controlled, within limits, by the position of the front standard. Distortion can be controlled by proper selection of camera position, lens placement, and front and back standard positioning.

CAUTION: Do not use excessive pressure to tighten locking knobs.

To tilt the front and/or rear standard. Loosen the vertical tilt lock knob, then tilt the standard into the desired position. Tighten the knob to maintain the required orientation of the standard (30° limitation).

To swing the front and/or rear standard. Loosen the horizontal swing lock knob, then swing the standard to the desired position. Tighten the knob to maintain the desired amount of swing (12° limitation).

To change the horizontal position of the front and/or back standard. Loosen the horizontal swing lock knob, then slide the standard to obtain the desired left or right location. Tighten the knob when the standard is properly positioned.

To raise or lower the lens. Press the rising front lock knob in, then turn it to position the lens. Release the knob to lock the front in position.

To rotate the back. Release the clamping lever, then turn the back to the desired position. Release the lever to retain the back in the desired position. (Rotation is unlimited.)

NOTE: Neutral positions of the horizontal swing and rotating back are indicated by spring ball catches. The rising/falling front is in neutral when it is centered with the vertical swing lock knob. Vertical swing and horizontal shift adjustments are neutralized by aligning the standards with their supporting frames.

Shutter operation. Once the camera is set up, taking the picture is relatively simple. Each "Calumet" lens has its own leaf shutter. The shutter speed is set by rotating a ring until the "V" indicator aligns with the desired shutter speed. The f/stop is set by aligning a rotating pointer with the appropriate f/stop. The shutter is cocked by depressing a lever on the side of the lens. The shutter is released by using a cable release (recommended for steadiest pictures) or by depressing another lever located at the top of the lens. The shutter also has provision for flash synchronization.

NOTE: For composing, the shutter is cocked and then a button on the side of the lens is depressed to hold open the diaphragm. By setting the diaphragm to the largest f/stop you will have the maximum brightness for viewing.

Exercise (228):

1. Complete the following statements on the description and operation of the "Calumet" view camera.
   a. The "Calumet" may feature either a __________ or ____________ inch bellows.
   b. The "Calumet" has ____________ __________ mounted on the top of the camera back to indicate whether the camera is level.
   c. Due to a __________ __________, any type of vertical or horizontal composition may be achieved.
   d. The "Calumet" uses ____________ __________ focusing.
   e. A view camera should be mounted on a __________ for use.
   f. The back focusing knob positions the ___ _______ __________.
   g. Initial focusing should be done with the __________ focusing knob.
   h. The "Calumet" lenses have __________ shutters.
   i. The "Calumet" features swing control to __________ degrees and tilt control to __________ degrees.

3-5. Copy Cameras

The term, copying, as used in photography, means the photographic reproduction of another photograph, drawing, map, chart, or similar flat-plane object. Reproductions of this type have a number of uses. Consider several examples. If a negative is lost or unavailable, a duplicate may be made by copying a print made from the original negative. Valuable documents, if used constantly, soon become worn and illegible; however, by making reproductions through the process of copying, you can preserve the original. On some occasions, it may be desirable to reproduce the subject at a different scale or size; this change, too, can be effected by copying.

Copy work, though it can be done by any type of camera, is best performed by specialized copy cameras. These cameras feature: (1) ground glass focusing, (2) both front and back focusing, (3) the necessary bellows extension to do at least 1-to-1 scale work, (4) process or apochromatic lens, (5) copy board to mount the subject matter, and (6) a lighting system that can be adjusted to provide even lighting. In this section we point out the features of the "Princeton" Model 17 which has these features.

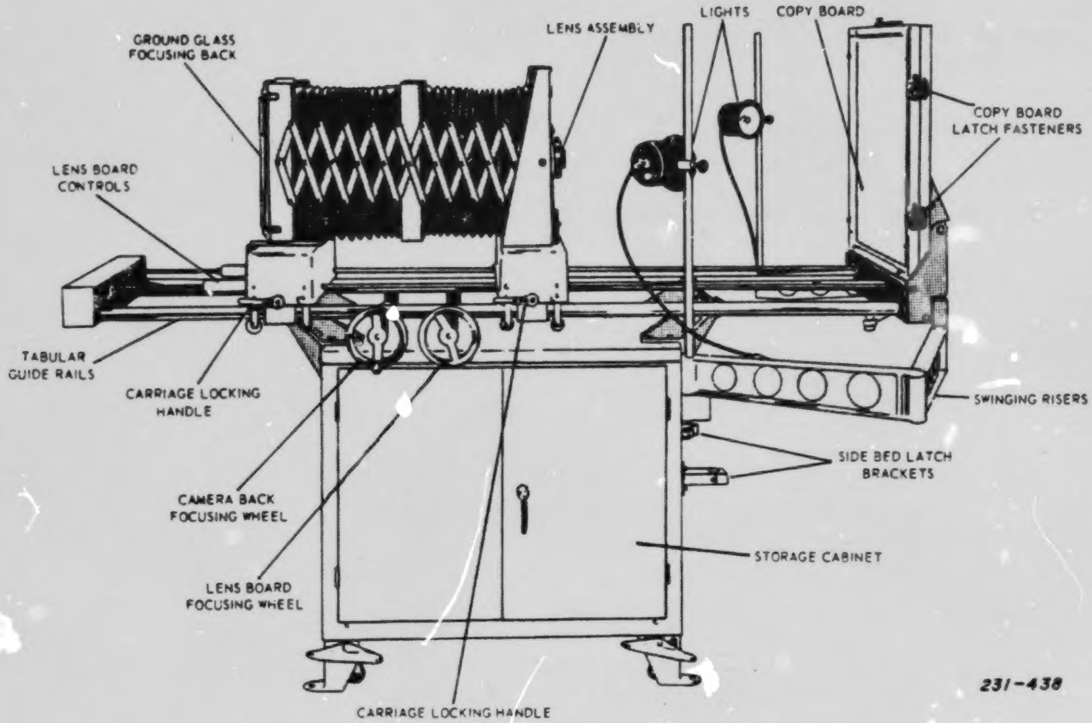


Figure 3-55. "Princeton" Model 17 Copy Camera.

229. Identify as accurate or inaccurate statements relating to the description and operation of the "Princeton" Model 17 copy camera.

"Princeton" Model 17. To illustrate basic copy camera features, let us zero in on the "Princeton" Model 17, which is illustrated in figure 3-55. The "Princeton" is a gallery-type copy camera. The camera is used in the horizontal position for copying continuous tone or line originals, from lighted copy or transparencies, black and white, or color work. In the vertical position, the camera is used for photography of exploded views, solid objects, printed circuits, and flat copy. The same base is used to support the camera in both positions. Conversion from horizontal to vertical position involves three actions: (1) unlatch, (2) pivot, and (3) latch.

Major components. The camera assembly consists of a lens carriage, back carriage, oversized bellows, camera back, adjustable light risers, and copyboard. All components are attached to two tubular guide rails, which extend the full length of the camera assembly. Control wheels on both the lens and back carriages provide precise movements of either lens or film positions along the tubular guide rails. A lockdown lever provides positive position control.

Carriages. The lens carriage accepts standard as well as recessed lensboards. The back carriage accepts a variety of conventional reducing backs as well as a zone controlled vacuum back.

Bellows. The bellows extends to 61 inches and contracts to a minimum of 11 inches. This extension accommodates lens focal lengths from 14 inches to 17¾ inches and provides a 1½ to 3¼ magnification or reduction ratio.

Camera back. The camera is equipped with a "Sta-Flat" back. The back contains a gelatin coated plate mounted in a frame with a darkslide. A separate ground glass screen is used for focusing. Standard reversible camera backs, revolving backs, and 100-foot magazine backs are available as accessory items.

Lights. Four 650-watt "Quartz-King" lamps on risers attached to swinging arms provide a full range of lighting control. A remote timer control and timer cord complete the lighting assembly.

1. MAGNIFIER—Enlarges a portion of the image for sharpest focusing. Swings out of the way for normal viewing.
2. VIEWER—Provides an accurate, full-sized image on hooded ground glass for composing and focusing.
3. CRANK FOR REWIND—Crank unfolds for ease of rewinding film into cassette.
4. CAMERA CASE LATCH—Secures the removable camera back.
5. CAMERA CARRIAGE LOCKING LEVER—Locks the camera carriage in final position after final focusing. Provides one-hand operating ease.
6. CAMERA TRAVEL KNOB—Moves the camera on a helical gear and rack mechanism for easy focusing.
7. LENS CARRIAGE TRAVEL KNOB—Large, easy to grasp knob provides quick and positive positioning of lens carriage.
8. WORK TABLE (EASEL)—Provides level work area of steel for smooth positioning. Easy to keep clean.
9. BASE—Cast metal housing for electronic flash light source. Design and finish both pleasing and functional.
10. THREADED HOLES—Drilled and tapped for 8/32 slide holder thumb screws.
11. NAMEPLATE AND CONTROL PANEL—Gives unit identification and directions for proper switch positioning.
12. READY LIGHT—Glows when the FLASH-VIEW switch is in the flash position, indicating that the Repronar is ready for coping—the view light is off, and the electronic flash is ready to be fired.
13. FLASH-VIEW SWITCH—In flash position, the switch completes the circuit for firing the electronic flash with the camera shutter release: in view position, the switch turns on the view light for illuminating the transparency.
14. HIGH-LOW SWITCH—Controls power output of electronic flash. When in the HIGH position the unit deliver four times (two f/stops) the amount of light as when in the LOW position. The power output in the LOW position is the same as the previous models of the Repronar.
15. ON-OFF SWITCH—Functions as the master switch for the Repronar. The view light and electronic flash operate only when this switch is in the ON position.
16. FILTER COMPARTMENT AND HOLDER—Filter holder slides in and out of the filter compartment easily, allowing insertion of filter without disturbing copy or opal view glass.
17. LENS CAP—Protects lens when not in use.
18. APERTURE SELECTOR—Controls the action of the lens diaphragm. Pointer indicates working aperture which is printed on the Aperture Index Scale.
19. f/STOP MARK—Indicates proper positioning of the diaphragm ring.
20. DIAPHRAGM RING—Rotates (click stops) to pre-select the proper f/stop. The Aperture Selector will stop when being moved from right to left, at the position indicated by the Diaphragm Ring.
21. APERTURE INDEX SCALE—Serves as an f/stop indicating scale for the Aperture Selector. Numbers on the scale represent full f/stops with half-stops indicated.
22. BELLOWS—Allows freedom of movement between camera body and lens.
23. CABLE RELEASE—Operates the shutter and fires electronic flash in synchronization.
24. FILM ADVANCE LEVER—Advances film and cocks the shutter in readiness for the next exposure.

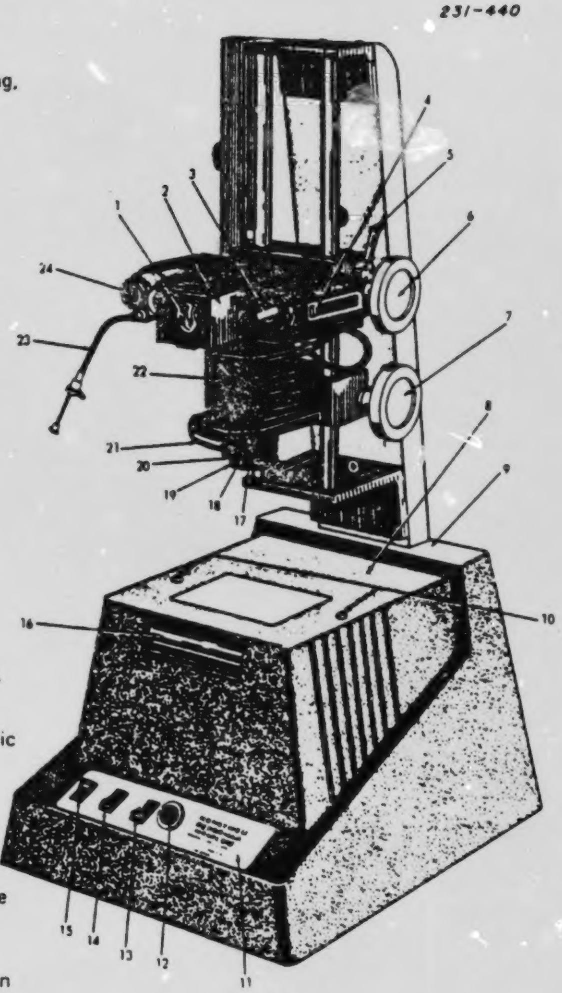
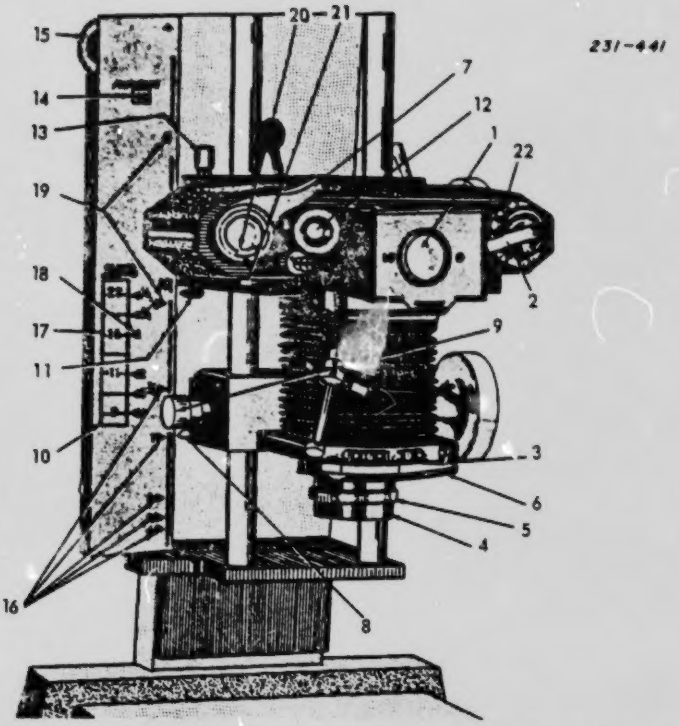


Figure 3-56. Repronar 805 slide duplicating camera.



1. MAGNIFIER—Enlarges a position of the image for sharpest focusing. Swings out of the way for normal viewing.
2. CRANK FOR REWIND—Crank unfolds for ease of rewinding film into cassette.
3. APERTURE SELECTOR—Controls the action of the lens diaphragm. Pointer indicates working aperture which is printed on the Aperture Index Scale.
4. f/STOP MARK—Indicates proper positioning of the diaphragm ring.
5. DIAPHRAGM RING—Rotates (click stops) to pre-select the proper f/stop. The Aperture Selector will stop when being moved from right to left. at the position indicated by the Diaphragm Ring.
6. APERTURE INDEX SCALE—Serves as an f/stop indicating scale for the Aperture Selector. Numbers on the scale represent full f/stops with half-stops indicated.
7. FILM ADVANCE LEVER—Advances the film and cocks the shutter in readiness for the next exposure.
8. LENS CARRIAGE POINTER—Indicates on the Exposure Calculator the magnification of the copy and the lens aperture for a normal exposure.
9. LENS CARRIAGE LOCKING SCREW—Locks lens carriage at selected position.
10. APERTURE WINDOW—Shows correct aperture settings for different amounts of magnification.
11. CAMERA CARRIAGE POINTER—Indicates settings to correspond with the lens carriage pointer, providing quick positioning of the camera for approximate focus. From this position, focusing is easily completed while the sharpness of the image is observed on the ground glass.
12. SHUTTER KNOB—Rotates as shutter is cocked (clockwise) and released (counterclockwise) Acts as selector for"I" and "B" settings.
13. MOTOR DRIVE LOCKING SCREW—Locks motor drive in proper position.
14. FILM INDEX WINDOW—Shows choice of film index.
15. SELECTOR WHEEL—For selecting proper film index.
16. MAGNIFICATION SCALE-LOWER—Used as reference points for the lens carriage pointer.
17. CAMERA APERTURE BAR—Gives correct aperture for various amounts of magnification.
18. MAGNIFICATION INDEX FOR APERTURE WINDOW—Used as reference points for exposure selection.
19. MAGNIFICATION SCALE-UPPER—Used as reference points for the upper pointer attached to the camera carriage.
20. EXPOSURE COUNTER—Shows how many frames have been exposed. Indicates numbers from—–2 to 37. Automatically resets to –2 when camera back is released.
21. DOUBLE EXPOSURE BUTTON—Allows the shutter to be cocked for multiple exposures without moving the film.
22. FILM REMINDER DIAL—May be used as a reminder as to what kind of film is in the camera body.

Figure 3-57. Repronar 805 camera and exposure calculator.

Copyboard. The standard copyboard, complete with pressure pad and cover glass, is 24 inches by 24 inches. The copyboard pivots to a horizontal position for loading. Additional accessories are available for holding transparencies and conversion of the copyboard to vacuum-type operation.

Base/storage cabinet. The camera assembly is pivot hinged to a sheet-steel storage cabinet, which serves as the camera base. The legs of the base are equipped with pedal-operated, retractable, swivel casters. When the camera is located in final position, the casters can be retracted and the base may be bolted to the floor, if desired.

Space requirements. The camera and base are 33 inches wide and 100 inches long. A ceiling height of 108 inches is required if the camera is to be operated in the vertical position. A minimum floor space of 105 inches by 148 inches is recommended to provide for operator movement about the camera.

Power Requirements. 115 volts AC, 60 Hertz, 2,600 watts.

Camera Format. 17 inches by 17 inches.

Exercise (229):

1. Identify each of the following statements regarding the description and operation of the "Princeton" copy camera as true or false.
   a. In the vertical position the "Princeton" copy camera is used to copy transparencies.
   b. In the horizontal position the "Princeton" copy camera is used to copy exploded views.
   c. For focusing, either the lens or the film can be moved.
   d. You can make a 100% enlargement on the "Princeton" copy camera.
   e. The "Princeton's" copyboard is lighted by six lights.
   f. The copyboard can handle a 16- x 20-inch photograph.
   g. The "Princeton" should be placed in a room with a 9-foot ceiling.
   h. The "Princeton" can use 8- x 10-inch sheet film for copy work.

3-6. Duplicating Cameras

In the Air Force there is an ever-increasing requirement for the production of slides for briefings, orientation of new personnel, and training aids. We can safely state that any subject that can be photographed or copied can be readily presented as a slide. Therefore, the production of duplicate slides in quantity is the main duplication task of a base photo laboratory that requires specialized equipment. There are presently a number of slide duplicating camera systems, but a common one that is widely available is the "Repronar" 805.

230. Complete statements about the description and operation of the "Repronar" 805.

The "Repronar" 805. The "Repronar" 805, illustrated in figures 3-56 and 3-57, is designed for color transparency (slide) copying. The instrument consists of a special purpose 35mm camera, an easel with slide and filter holders, an electronic flash light source with high and low output control, an incandescent light source for viewing the transparency to be copied, and an adjustable exposure calculator.

The camera is a single-lens reflex type with an f/4 lens designed for copying. It features a rapid film advance lever and film rewind crank. A shutter-cocking device permits multiple exposures. Both the camera and the lens carriage move smoothly on a helical rack to vary the magnification and to achieve sharp focusing. A ground glass allows direct viewing for composition, and a magnifier lens assures critical focusing. The bellows adjusts for copies of any degree of magnification from 4X enlargement to 1/2 reduction. (The 1/2 reduction can be used to copy 120 2¼ x 2¼ transparencies onto 35mm film.)

The exposure calculator is set by dialing the film value for the emulsion used in duplicating the slides. (Film value numbers are given in the instruction manual for different films.) The calculator has a camera aperture bar that indicates the correct aperture. The correct aperture is primarily affected by the film value and the degree of magnification.

The built-in electronic flash unit has a high-low switch in the base which permits a 4X light ratio. The selection of high or low will influence the film value used to set the exposure calculator.

Operation. The "Repronar" camera is loaded (and unloaded) like other 35mm reflex cameras. Once the camera is loaded the following steps are taken to duplicate a slide:

1. Set the on-off switch to the on position.

2. Push the flash-view switch to the view position.

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3. Be sure the film has been advanced and the shutter cocked before focusing and composing.

4. Open the aperture selector to f/4 to give maximum illumination for viewing.

5. Place the transparency to be copied emulsion down in the slide holder. (Color or black-and-white negatives to be copied are placed emulsion up.)

6. Establish the correct magnification by adjusting the lens and camera carriages. Composition may be established through a combination of magnification and moving the slide holder on the easel.

7. Set the correct aperture as indicated by the aperture bar.

8. Push the flash-view switch to flash.

9. Depress the shutter release making the exposure.

10. Turn the film advance lever a full stroke to advance the film and cock the shutter for the next exposure.

NOTE: To reemphasize, correct exposure and filtration depend on the duplicating film that is being used. The instruction book outlines starting points for calculation of

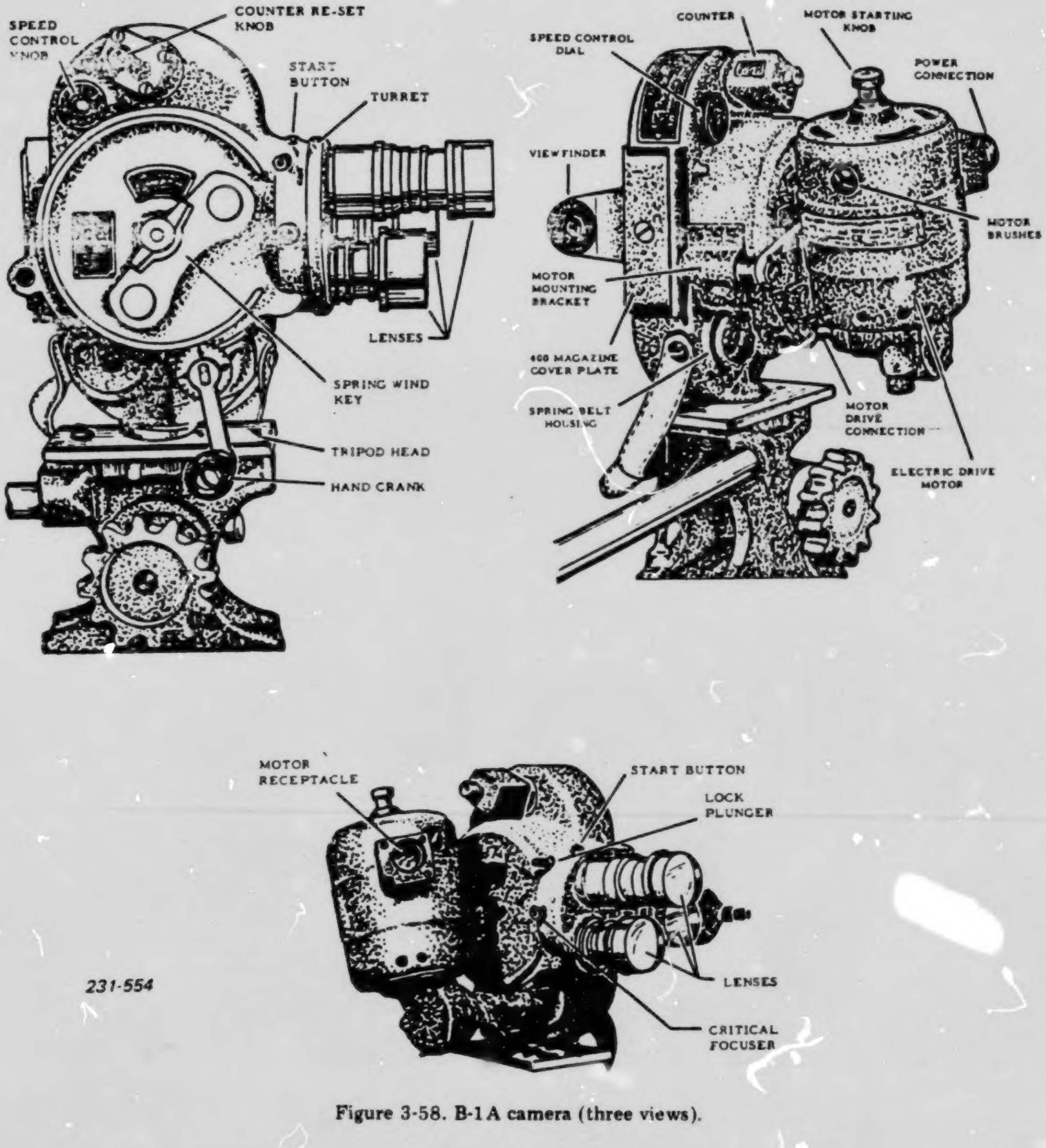

Figure 3-58. B-1A camera (three views).

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exposure. It is best to run tests to insure proper results.

The "Repronar" is quite versatile. Both black-and-white and color films can be used. During duplicating, correction can be made for underexposure, overexposure, and color balance. Special effects can be created through the use of sandwiches (i.e., creating an image from more than one slide) vignetting, texturing, and cropping, etc.

Exercise (230):

1. Complete the following statements on the description and operation of the "Repronar" 805.
   a. The "Repronar" uses a ____________ camera for copying.
   b. An ____________ ____________ provides the exposure light on the "Repronar."
   c. Both the ________________ and the ____________ __________ move to vary the magnification and achieve sharp focus.
   d. By making a ___________ reduction you can copy 120 slides onto 35mm film.
   e. The high switch on the electronic flash provides an intensity _____________ greater than the low switch.
   f. A transparency to be copied is placed _____________ __________ in the slide holder.
   g. Unlike most cameras, the "Repronar" does not have ___________ speeds.
   h. Color negatives are placed ____________ ___________ in the slide holder.

3-7. Silent Motion Picture Cameras

Though your job description emphasizes the use of still cameras and there is a separate AFSC for motion picture cameramen, nevertheless, there may be a need for silent motion picture coverage. Such footage is likely to be used for local television news releases or perhaps in the support of training. The description of the B-1A that follows is an introduction to motion picture camera operation. Since your use of motion picture equipment is likely to be infrequent, it would be a good idea to carefully review all operation procedures of the equipment assigned to you before going out on the mission.

231. Complete statements describing the B-1A camera.

The B-1A Camera. The type B-1A "Bell and Howell" 70-KM camera shown in figure 3-58 is a compact, portable, motion-picture camera designed for use with standard 16mm film. Although no tripod has been included with the camera accessories, the camera is equipped with a bronze insert threaded with standard tripod threads. The surface of the camera around this tripod insert, or socket, is accurately machined for vertical and horizontal alignment. When mounted on a tripod the camera shows greater stability and permits smoother pans.

Provision has been made on the back of the camera frame for mounting a 400-foot magazine. The magazine is made of diecast aluminum and weighs approximately three pounds. The film chambers of the magazine are lined with velvet cloth and are precision-machined. Removable covers eliminate the possibility of light entering the film chambers during operation.

A 24-volt, direct-current electric motor used for magazine operation is small and compact and can be quickly and easily installed on the camera. This unit has a gear reduction of 21-to-1 and weighs approximately 3½ pounds. A special cord plugs into the two-prong receptacle on the side of the motor housing.

The camera frame is a die-cast housing, and its rigidity assures accurate alignment of mechanism parts, lens and film-moving parts. All parts have been manufactured to within extremely close limits to assure the accuracy and precision which are necessary for even and constant speed regulation. These close tolerances also assure accuracy of film registration at the aperture, providing steadier projected pictures.

The film chamber of the camera accommodates film spools up to 100-foot capacity. The counter near the top of the camera frame accurately counts off each foot of film as it runs through the camera. The counter can be set manually at the start of each run by turning the counter knob clockwise until three zeros appear in the window. The counter operates in the forward direction only and continues to run forward even when backwinding the film with the hand crank. This must be taken into consideration and the footage calculated whenever the film is backed up.

A rotating turret head with three lens openings permits the use of lenses of varying focal length or aperture. The lens mounts are threaded and the focal length accurately machined for standard C-type, thread-mount lenses. The lenses can be shifted quickly and easily into photographic position merely by rotating the lens turret in either direction. Index rollers locate the turret so that the axis of the lens being used coincides with the center of the aperture. An interlocking arrangement between the turret and the camera starting-button makes it impossible to operate the camera unless the axis of the lens is properly aligned with the aperture.

Certain lenses cannot be mounted together on the lens turret because the longer lens may interfere with the field of the shorter lens. The following chart lists those lenses that can be used together:

Shortest Lens on Turret	These longer lenses may be mounted on the turret with the shorter lenses listed in the left-hand column, but they must be focused on infinity to reduce their length to a minimum				
17mm	1-in.	2-in.			
1-in.		2-in.	3-in.	*4-in.	
2-in.			3-in.	4-in.	6-in.
3-in.				4-in.	6-in.

The viewfinder can be completely detached from the camera cover. The viewfinder turret accommodates the three objective lenses which match the focal length of the camera lenses, and a spring-loaded detent positively locates the objective lens in line with the eyepiece of the viewfinder. A spacing block between the camera cover and the viewfinder tunnel provides a means for eliminating interference when the magazine is installed on the camera.

When the turret is rotated to bring the lens 180° from the photographing position, the lens then is located for focusing visually in the critical focuser. This device consists of a prism, a ground glass, and a magnifying lens. It gives the operator a magnified view of the center of the film frame. With this critical focusing device, the lens focusing mount can be rotated until the image is sharp on the ground glass. Since the ground glass is in the same plane as the film emulsion, sharply focused pictures on the film are assured. Focusing also may be accomplished by adjusting the calibrated focusing scale on the lens mount to agree with the exact distance from lens to subject.

For short, intermittent runs, the camera can be loaded with film and then operated with the spring motor. The powerful spring motor has a capacity of from 21 to 23 feet of film on one full winding of the winding key. Through a series of gears, a high-speed governor mechanism maintains a constant running speed throughout the entire run of film. The standard running speed for silent motion pictures is 16 frames per second. In addition to these speeds, the camera is calibrated to operate at speeds of 8, 12, 32, 48, and 64 frames per second. The speed is controlled by a dial located near the top of the camera frame where it is accessible for quick change from one speed to another. The speed remains at one setting until changed and does not change of its own accord while the camera is in use.

The intermittent movement of the film at the aperture is obtained with a shuttle which enters and withdraws from the film at right angles. This shuttle registers the position of the film at the aperture with sufficient accuracy to obtain steady pictures during projection, even on large screens.

The camera shutter is of the rotary-disk type with an opening of 204°. It is geared directly to the film movement mechanism and cannot get out of synchronization. The 204° opening allows an exposure time of 1/27 second when the camera is running at 16 frames per second. The following lists the shutter speed at the various camera speed settings:

Camera Speed	*Shutter Speed*
8 frames per second	1/13 second
12 frames per second	1/20 second
16 frames per second	1/27 second
24 frames per second	1/40 second
32 frames per second	1/53 second
48 frames per second	1/80 second
64 frames per second	1/107 second

The camera is started by pressing the starting button located just in back of the turret head. When the starting button is released, the mechanism will stop with the shutter in a closed position. Only when the camera is allowed to run down is there a possibility of the shutter stopping in the open position. The starting button lock makes it possible to lock the starting button in the "run" position. This is most useful when the camera is mounted on a tripod, because it allows the operator to leave the camera and enter the scene with the camera running.

Exercise (231):

1. Complete the following statements on the description of the B-1A camera.

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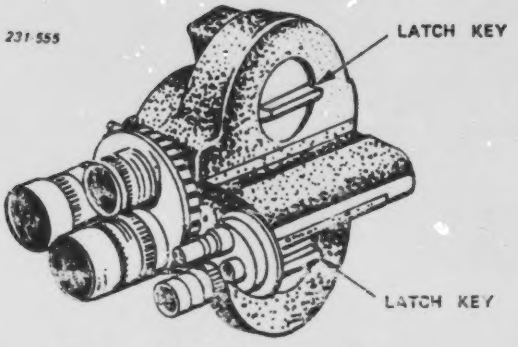


Figure 3-59. B-1A camera (left view).

a. The B-1A camera uses ___________ film.

b. The film chamber will hold a ___________ foot magazine.

c. You use a ___________ volt motor when using the _____ _____ magazine.

d. The rotating lens turret can hold ___________ lenses.

e. If your shortest lens is 3 inches, the other two lenses should be ___________ and ___________ inches.

f. The two methods of focusing the camera are by using the ___________ ___________ and the calibrated ___________ ___________.

g. The standard running speed for silent motion picture footage is ___________ frames per second.

h. The B-1A has a ___________ ___________ type shutter.

i. When the camera is set at 24 frames per second, the shutter speed is ___________ of a second.

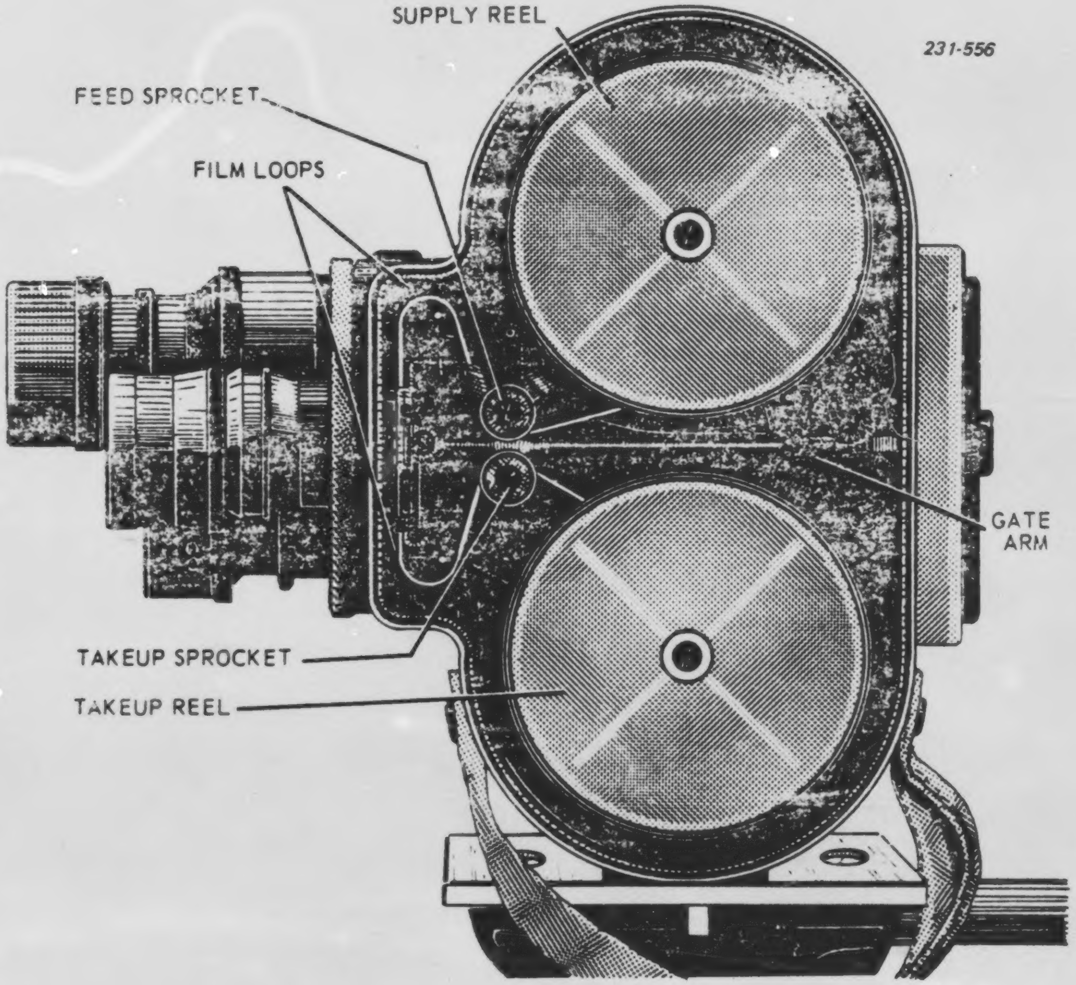


Figure 3-60. B-1A camera (internal).

232. Identify principles related to the operation of the B-1A camera.

Motion Picture Camera Operation. A motion picture camera requires careful operation to achieve maximum performance. The following will be a brief rundown on the major operational procedures in using the B-1A.

Loading film. The camera must not be loaded or unloaded in direct sunlight. Find a shaded spot, or shield the camera from the direct rays of the sun with your body. Film which has been spooled for darkroom rather than daylight loading must of course be handled in a darkroom. Consider the following steps when loading the camera.

1. Remove the cover from the camera as shown in figure 3-59 and open the film gate by pushing the gate arm toward the back of the camera as far as it will go. An intermediate stopping point can be felt when the gate is partially open, but the gate arm should be pushed on back until the upper and lower sprockets are drawn away from their guide shoes.

2. Remove the spool of film from its metal container, and unreel about 18 inches of the film leader. On film where a paper leader is not provided, the first 6 feet of the film serves for threading and as a light-proof protective leader.

CAUTION: During this and all succeeding operations, keep the film wound tightly. If it is permitted to loosen, light may enter and fog the film on its edges. The camera spring must be partially wound.

3. With the square hole in the spool face down and the leader feeding off the spool to the left, place the spool over the feed spindle. Make certain that the two floating film-guard rollers are outside the film.

4. Thread the film around the feed sprocket so that it is between the upper film-guide shoe and the sprocket. Leader perforations must be engaged with the sprocket teeth (see fig. 3-60).

5. Place the leader in the film gate channel, shown in figure 3-60, leaving enough slack above to form the upper loop. The extreme top of the loop should be about 1/4 inch from the metal camera shell.

6. Leaving the lower loop approximately the same size as the upper loop, insert the leader between the take-up sprocket and the lower film guide shoe. Engage the sprocket teeth with the perforations in the leader as shown in figure 3-60.

7. Engage a pair of film leader perforations with the two shuttle teeth at the bottom of the aperture plate. Make sure that the leader perforations still are engaged with the feed and takeup sprocket teeth and with the shuttle teeth. Check to see that the upper and lower loops are still the proper size; then close the film gate by pushing the film gate arm toward the front of the camera as far as it will go as illustrated in figure 3-60.

NOTE: Be careful not to stop at the intermediate stopping point. The gate should be pushed up firmly against the film. The camera cover cannot be installed unless the film gate is completely closed.

8. Moisten the end of the film and insert into the hub slot of the takeup spool. Then revolve the spool in a clockwise direction to take up the slack in the leader, and place the spool over the takeup spindle.

9. Test the correctness of the loading and threading by pressing the starting button quickly and momentarily a few times, meanwhile watching to see that the leader runs through the sprockets and aperture channel and that it is being taken up by the takeup spool. Correct any errors which are discovered by this test.

NOTE: Avoid running off more than 6 inches of film during the test. This 6 inches, together with the 18 inches used in threading and the 4 feet to be run off with the camera cover in place, complete the 6 feet which is cut off the roll (as a leader) when the film is developed.

10. Install the camera cover and turn the two latches one-quarter turn to the closed position. The camera must not be opened again, except in a darkroom, until the entire reel has been exposed.

11. Turn the counter reset knob counterclockwise until three zeros are visible in the counter window. Then press the camera starting button and allow 4 feet of film to run through the camera. This 4 feet comprises the amount of film leader which was left on the spool when the threading and testing was completed. Reset the counter to zero. The film now is at the aperture and the camera is ready for spring motor operation.

Winding the spring motor. When operating the camera without the electric motor and magazine, the driving spring must be wound to provide "power" for the camera. Wind the spring by turning the winding key in a counterclockwise direction until a definite mechanical resistance is encountered. Do not force the spring. Because of the ratchet design of the key, the same backward and forward motion employed when winding a watch may be used in winding the spring. Grasp the viewfinder tube firmly with the left hand and the winding key with the right. After winding, fold the key flat against the side of the camera. If left erect, the key will rotate as the camera runs.

NOTE: It is always advisable to wind the motor fully after each operation of the camera. Thus, the full capacity of the motor is available at all times in case an unexpected demand for an extended run of film should arise.

Focusing the lens. The lens must be adjusted so that it will focus sharply on the subject being photographed. Measure as accurately as possible the distance from the lens to the subject. A knurled ring around the lens is calibrated for various distances. Revolve the ring until the designated distance is aligned with the index mark on the lens housing. The lens then will be sharply focused at a point corresponding to this number of feet from the film plane. It is desirable to check this setting of the lens focusing mount before each picture is made.

Using the critical focuser. The camera also may be focused by using the critical focuser. Revolve the turret head 180° to bring the lens which is to be focused around to the critical focuser on the right-hand side of the camera. This brings the lens in position to focus the image on a ground glass within the focuser, and a lens provides a greatly magnified image of the central portion of the scene. With the lens diaphragm at its widest opening, sight through the focuser and manipulate the lens focusing ring in the usual manner until the image on the ground glass is sharp. After focusing, return the lens to the photographic position. The critical focuser is to be used only for focusing the lens and not for composing the picture. Use the viewfinder for that purpose.

Choosing the proper speed. The standard speed for running silent films is 16 frames per second and normally should be used for general photography. The slower speeds (8 and 12) are useful for speeding up sluggish action and for gaining greater exposure through the slower shutter speeds (1/4 second and 1/21 second respectively). The need for greater exposure is particularly true when light conditions will not permit exposure at the widest lens aperture during normal speed (16) operation. A speed of 64 frames per second will give a slow motion effect. A speed of 48 frames per second is used to advantage for scenes taken from fast-moving objects. The 24 and 32 speeds are recommended for panoramic shots, because these speeds minimize irregular motions of the camera. The 24 speed is standard for running film and should be used regularly if sound is to be added.

Setting the camera speed. When operating the camera with the electric motor, the camera speed must be set above 24 frames per second. When operating with the spring motor, any one of the speeds from 8 to 64 frames per second may be used. After selecting the speed most adaptable to your particular need, adjust the camera speed dial accordingly. Note that the outer knurled ring of the speed dial revolves about the disc upon which the seven speeds are indicated. To adjust the speed, turn the outer knurled ring until its index mark coincides with the index mark notched into the edge of the segment in which the desired speed is stamped.

NOTE: Changing the camera running speed affects the camera exposure time to a corresponding degree. Therefore, whenever the camera running speed is changed, the lens diaphragm setting also must be changed.

Setting the lens diaphragm. The size of the lens opening depends upon the speed at which the camera is set. The faster the speed setting, the greater the lens opening must be. Further consideration also must be given to the various lighting conditions and the various subjects being photographed. For example, the lens opening used when photographing a marine scene on a bright, cloudless day would not need to be as great as when photographing the same scene under a heavy overcast. Use any approved motion picture exposure calculator to obtain the correct diaphragm setting to be used for your particular lighting condition, type of subject, and speed setting. Then adjust the lens diaphragm ring to the proper opening.

Holding the camera. Screw the stud of the support handle up into the tripod socket of the camera. Slip the left hand through the handle strap, and grasp the handle firmly with the strap supporting the wrist. Steady the camera by pressing it firmly against the forehead, meanwhile sighting through the viewfinder eyepiece with the left eye. The eye should be even with the viewfinder to eliminate squinting the camera with a rigid support. Hold the camera steady during the entire photographic operation.

NOTE: When using telephoto lenses, it is advisable to mount the camera on a tripod, because any slight movement of the camera is greatly exaggerated when the resultant pictures are projected.

Setting the viewfinder. Rotate the viewfinder turret until the proper focal length objective lens snaps into position at the top of the turret. The area seen through the viewfinder eyepiece is now the same as the area being covered by the lens in use.

Operating camera with spring motor. With the subject framed in the viewfinder, press the starting button to begin taking pictures. As soon as the button is pressed, the hum of the motor indicates that the camera is running. Hold the starting button down until the scene is to be concluded—then release the button. When the camera mechanism is properly adjusted, it will run not less than 21 feet and not more than 23 feet of film on one complete winding of the main drive spring. On extended runs of film, the starting button can be locked in the running position by holding down the starting button and then pressing in the starting button lock. The camera then continues to run until the drive spring has run down or until the starting button lock is pulled outward.

NOTE: When operating the camera with the drive spring motor, do not attempt to use the magazine. The magazine must be used only in conjunction with the electric motor.

Operating the camera with electric motor and magazine. When it is used with the electric motor and magazine, mount the camera on a tripod. The base of the camera is equipped with an insert which is threaded with standard tripod threads. Thus it is possible to mount the camera on any standard tripod. Make certain that the tripod is placed to give it the most solid footing possible. Remember that the camera speed must be set above 24 frames per second when using the electric motor and that the camera starting button must be locked down with the starting button lock.

Safety locking device. If desired, the starting button may be locked to prevent accidental starting of the camera while it is not in use. This is accomplished by revolving the turret head until any one of the three index dots on the edge of the head is opposite the word "LOCK." When ready to begin taking pictures, turn the turret head until the lens to be used is in front of the aperture when one of the index dots is opposite the word "RUN."

Using the hand crank. Use the hand crank for photographing only when the camera is rigidly and securely mounted on a tripod. Allow the spring motor to run down completely by locking the starting button in the running position. Insert the hand crank into the hand crank housing turning the crank shaft until it engages the lug within the housing. A full 100-foot roll of film can be exposed without a stop by turning the hand crank in a forward (clockwise) direction. The speed dial controls the camera running speed even when the hand crank is used. Therefore, it is not possible to crank the camera faster than the speed for which the dial is set. Always crank with a steady, even pressure.

Backwinding the film. NOTE: For trick effects, such as lap-dissolves and superimposing titles on moving backgrounds, it is necessary to backwind the film. The hand crank and rewind knob are supplied for this purpose. Before beginning backwinding operation, place a lens cap or other suitable cover over the lens to avoid exposing the film. The spring motor must be run down at least 2 feet before backwinding is possible.

Hold the hand crank firmly to prevent forward movement of the film, and hold, or lock, the starting button in the running position. Then turn the hand crank counterclockwise to backwind the film. Each complete revolution of the hand crank moves 20 frames (1/2 foot) of film past the aperture. Limit the backwinding to two complete revolutions at a time. Be sure to release starting button after each hand crank operation.

After each hand crank operation, press the rewind knob inward to engage it with the feed spool and turn the knob counterclockwise to take up the film on the feed spool. Be careful not to force the knob or the film may be torn or damaged. When using the magazine, film which was backwound may be taken up on the magazine feed spool by turning the upper magazine pulley in a clockwise direction.

The above steps may be repeated until the desired amount of film footage has been rewound on the feed spool.

NOTE: The camera counter is directly geared to the camera mechanism, and it moves forward even when the hand crank is winding the film in reverse. After backwinding, therefore, make a note of the amount of film which was rewound and multiply that amount by two. When the counter indicates that the end of the roll of film has been reached, you will know that there is still a small amount of film which can be run. For example, if, during the course of a 100-foot roll of film a total of six feet has been backwound, twelve feet of film will be left on the roll even though the counter indicates that the entire roll has been run.

Making double exposures. To make a simple double exposure (in which the same length of film is exposed twice), complete the first exposure by pressing the camera starting button. Then place a lens cap over the lens and backwind the film as instructed in the last paragraph. After the film has been backwound, once more start the camera. This superimposes the two pictures.

Fadeins and fadeouts. As the name implies, a fadein starts at the beginning of a scene with solid black and gradually becomes lighter until a picture of normal density is reached. A fadeout comes at the end of the scene and means that the picture becomes increasingly darker until it is totally blacked out. Fading can be accomplished by closing or opening the lens diaphragm. When working with small diaphragm stops on brightly lighted scenes, a fader attachment is desirable, because it is impossible with most lenses to stop the lens diaphragm down sufficiently to get a complete fadeout. Neutral density filters can be used to permit shooting the picture at a larger lens diaphragm opening, thus obtaining a larger range of diaphragm movement for making the fade. The neutral density filter does not affect either color or a black-and-white rendering. To make a fadein with the lens diaphragm, first set the diaphragm to its smallest opening. Place a finger over the end of the lens shade and allow the camera to run for a few frames. With the camera running, steadily remove the finger and slowly revolve the diaphragm ring until it reaches the setting for the correct exposure of the scene being photographed. To create a fadeout at the end of the scene, slowly revolve the diaphragm ring to its smallest opening. Then place a finger over the end of the lens shade and, after three or four frames, stop the camera.

Creating a lap-dissolve. A lap-dissolve is the transition from one scene to another wherein the first scene fades gradually and almost imperceptibly into the second with no abrupt breaks. This is accomplished by superimposing a fadein over a fadeout. Fading out can be accomplished by closing the lens diaphragm gradually, or by using a fader device. The film is then wound back to the start of the fadeout. The film is then started again with the fadein shot which requires that the diaphragm be gradually opened to the shooting aperture.

Unloading the camera. After the counter indicates that a roll of film has been completely exposed and that approximately five feet of trailer has been run through the camera, the camera door may be removed. Take the spool of exposed film out of the camera, holding it firmly to prevent any unwinding or loosening. Place the spool immediately in the safety metal container in which it was received.

CAUTION: The camera should be unloaded in a dark or shaded spot. In any case, do not expose the roll of film to the direct rays of the sun. Film designated for darkroom loading and unloading must not be exposed to light. Hold the roll of film firmly so that it does not unwind during the unloading process, as this may fog the edges of the film. Then place the exposed roll of film directly into the film can.

Exercise (232):

1. Complete the following statements on the operation of the B-1A camera.

   a. Daylight film loads are not loaded in ______ sunlight.
   b. The first ______ feet of film is used as a leader.
   c. __________ frames per second is the normal speed for silent movies.
   d. __________ frames per second is the running speed for sound work.
   e. A very high shutter speed will give a ____________ __________ effect.
   f. A very slow shutter speed will ___________ up the action.
   g. When the camera running speed is changed, the _____________ must be changed to ensure even exposures.
   h. When using a telephoto lens, the camera should be mounted on a ____________ ; otherwise camera movement will be ____________ .
   i. When using the electric motor, the shutter speed should be set at ___________ frames per second.
   j. A full hundred-foot roll of film can be exposed nonstop by use of a _________ ______________ .
   k. Fades can be accomplished by ______________ or ______________ the _______ .
   l. A ______________ __________ is a transition where one scene fades into another.
   m. The critical focuser is used for ______________ and not for ________ .
   n. To superimpose a title on a moving background you need to ___________ the film.
   o. The counter moves forward even when you are ________________ .

CHAPTER 4

Photographic Optics

PHOTOGRAPHIC optics is a science concerned with the principles and characteristics of lenses, and with the way these principles and characteristics affect the transmission of light. Photography owes its present state of advancement as much to the development of fine lenses as to anything else. A photographer is better qualified when he can recognize the capabilities and limitations of the lenses he uses. In this chapter, we introduce a number of optical terms and principles to enable you to apply them in your photographic assignments.

4-1. Focal Length

"Focal length" is a term that is used to identify every lens. Therefore, it is a term you should be familiar with.

233. Define the term focal length.

The term "focal length" is defined as the distance from the optical center of the lens to the image produced by the lens at the focal plane, when the lens is focused on infinity (see fig. 4-1). The optical center of a lens is a point, usually within a lens, at which the rays of light from different sources entering the lens are assumed to cross. For normal lenses, "infinity" is a condition that exists when light rays from distant objects enter the lens in a nearly parallel attitude. When the lens is focused at infinity, objects beyond the nearest point of infinity are always in focus. The focal length is expressed in inches or millimeters, and usually is engraved on the lens barrel.

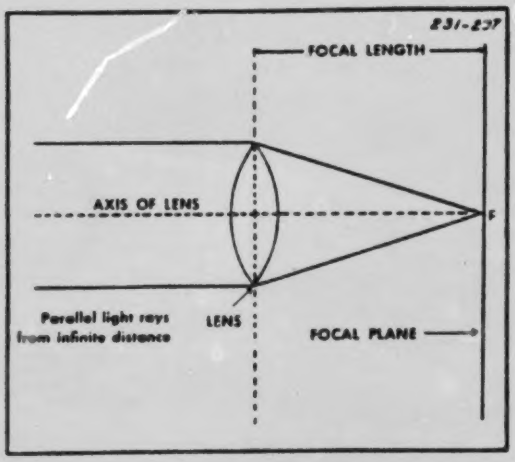


Figure 4-1. Focal length of lens.

Exercise (233):

1. Define focal length.

4-2. Lens Speed and Aperture

Lens speed and aperture selection are important concepts in the selection of a lens and in the calculation of exposure. In this section each of these concepts will be discussed.

234. Briefly explain how f/stops are calculated and the effect that f/stop changes have on the amount of light striking the film.

The aperture is the opening inside the lens that permits light to pass through to the film when the shutter is open. The size of the aperture is controlled by a diaphragm. The actual size of the aperture is controlled by a diaphragm. The actual size of the aperture for a given diaphragm setting is indicated by a particular f/stop number which is engraved on

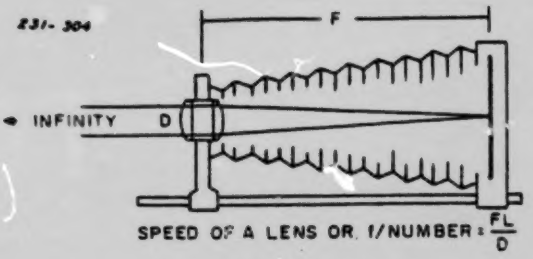


Figure 4-2. The f/number of a lens.

the diaphragm ring. You must have a thorough understanding of how these f/stops are calibrated because the f/stop or aperture setting is one half of the basic exposure formula.

Calculating F/Stops. F/stops are calculated by dividing the focal length of the lens by the diameter of the aperture. This is expressed in the formula $f\ (f/stop) = \frac{FL\ (Focal\ Length)}{D\ (Diameter)}$.

For example, if the focal length is 6 inches and the diameter of the particular aperture is 1½ inches, the f/stop setting would be f/4, see fig. 4-2. Because the f/stop is a ratio between the focal length and the diameter of the aperture, all lenses set at the same f/stop, regardless of focal length, give the same intensity of light on the focal plane, all other factors remaining the same (see fig. 4-3).

Using the formula FL/D as a basis and starting at 1, f/stops have been calculated and put into a series in which each successive number indicates an opening that admits one-half as much light as the opening indicated by the previous f/stop. These f/stops, sometimes called full stops, are 1, 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, 32, 45, and 64. The important point to remember is that as the number increases, the amount of light admitted is double for each full stop.

All good lenses have an adjustable diaphragm to control the aperture of the lens. As the diaphragm is rotated to change the aperture, the appropriate f/stop is aligned with an indicator mark. The f/stops marked on the lens barrel are not always full stops. Due to lens design they may start at a half-stop or a three-quarter stop. In such cases, the next f/stop is usually a full stop. To insure accuracy in figuring the exposure from one f/stop to the next, the full stops should be learned.

Exercises (234):

1. Briefly explain the formula for the calculation of f/stops.

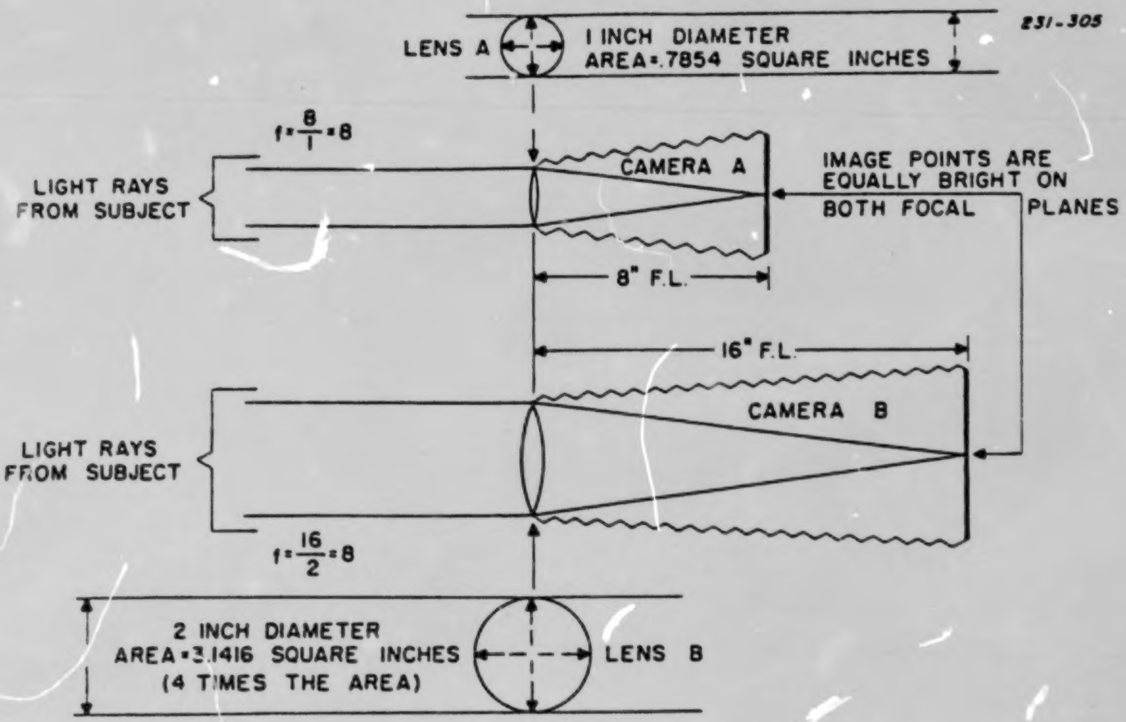


Figure 4-3. Equal f/numbers produce equal intensities.

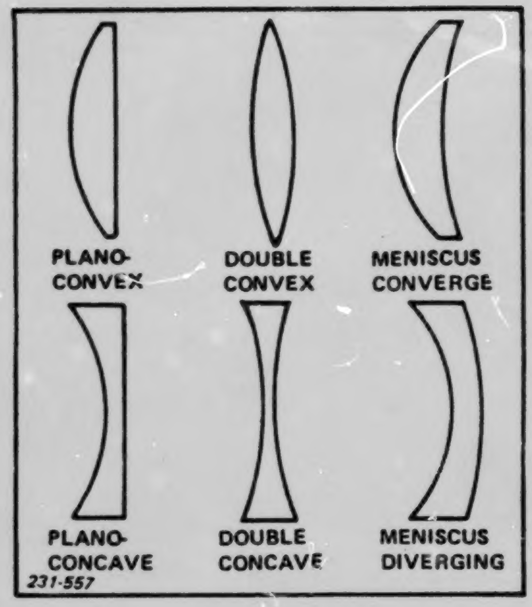


Figure 4-4. Positive and negative lens types.

2. Explain how changing to the next smaller or next larger f/stop changes the amount of light striking the film.

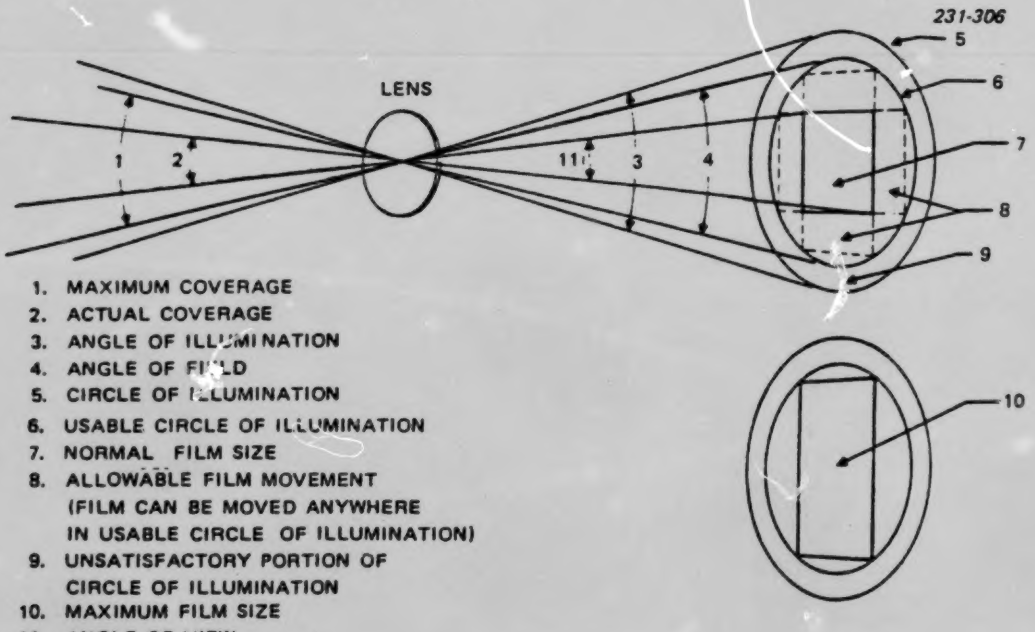
235. State how lens speed is calculated.

Lens Speed. Lens speed is used to express the light gathering power of a lens. A "fast" lens makes available a lot of light for exposure. A "slow" lens makes relatively little light available. The speed of the lens is calculated by dividing the focal length of the lens by the diameter of the *maximum* aperture. For example, a lens with a focal length of 100mm and a maximum aperture diameter of 50mm would be called a f/2 100mm lens. If the diameter of the maximum aperture was only 25mm, the lens would then be a f/4 100mm lens.

Normally, the faster lenses of a given focal length have more lens elements, are larger, heavier, and more costly. Fast lenses are helpful in low light situations or when slow speed film is being used.

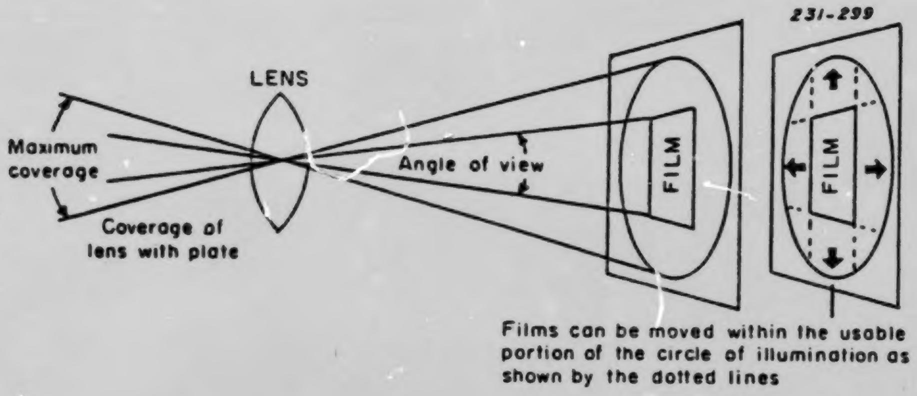
Exercise (235):

1. Explain how the speed of a lens is calculated.



1. MAXIMUM COVERAGE
2. ACTUAL COVERAGE
3. ANGLE OF ILLUMINATION
4. ANGLE OF FIELD
5. CIRCLE OF ILLUMINATION
6. USABLE CIRCLE OF ILLUMINATION
7. NORMAL FILM SIZE
8. ALLOWABLE FILM MOVEMENT (FILM CAN BE MOVED ANYWHERE IN USABLE CIRCLE OF ILLUMINATION)
9. UNSATISFACTORY PORTION OF CIRCLE OF ILLUMINATION
10. MAXIMUM FILM SIZE
11. ANGLE OF VIEW

Figure 4-5. Circle of illumination.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LENS
Maximum coverage
Coverage of lens with plate
Angle of view
FILM
FILM
Films can be moved within the usable portion of the circle of illumination as shown by the dotted lines

Figure 4-6. Angle of view.

4-3. Circle of Illumination

The circle of illumination projected by a lens is a concept that should be understood by all photographers and has important practical consequences to users of view cameras.

236. Define circle of illumination and the usable circle of illumination.

Every positive lens projects a circular field of light. A positive lens converges rays of light toward the lens axis to form image points. A negative lens, which is unsuitable for photography, causes the rays to diverge. A positive lens is easy to identify because it is thicker in the center than at the edge, while a negative lens is thicker at the edges (see fig. 4-4). If the circle of illumination is inspected from the center towards the edge, it is seen that at first the illumination falls off gradually; but out near the edge as the concentration of light rays diminishes, it falls off very rapidly. The usable circle of illumination is determined by including only that portion of the total circle of illumination that has sufficient intensity to produce satisfactory images. This usable circle of illumination sets limits on the film size that can be used and the amount of corrective adjustment (such as those found on view cameras) that can be made before there is a serious loss of quality (see fig. 4-5).

Exercises (236):

1. Define circle of illumination.

2. Define the usable circle of illumination.

4-4. Angle of Field and View

Angle of field and angle of view are terms that are dependent on two concepts you have just learned: focal length and circle of illumination.

237. Define angle of field and angle of view.

The focal length of a lens is a determining factor in the coverage of a lens. The maximum coverage of a lens is expressed in degrees as the angle of field. The angle of field of a lens is the widest angle at which light enters the lens and produces the usable portion of the circle of illumination. The maximum size of film that can be used with a lens depends on the angle of field, since any part of the film extending beyond the usable circle of illumination yields an indistinct image.

The size of the film ordinarily used with a lens is also limited by adjustments of the lens and film position. This necessitates the use of a smaller size film, due to the fact that such adjustments sometimes move the film about in the circle of illumination or the position of the circle of illumination is changed by moving the lens. The angle of view of a lens is, therefore, the angle of light that is necessary to provide adequate coverage of the film that is being used. It is, therefore, never greater than the angle of field. Review figure 4-5 and study figure 4-6.

Exercise (237):

1. Define angle of field and angle of view.

4-5. Resolution and Definition

Resolution and definitions are terms that are used to describe the "sharpness" or image quality produced by a given lens.

238. Define resolution and definition and briefly explain how they are determined.

Resolution. The term resolution or resolving power refers to the ability of a photographic lens or material to record fine detail. The normal method of measuring this quality is to photograph a suitable test pattern at a greatly reduced scale, and then examine the developed image under adequate magnification to calculate the smallest detail that is resolved. Resolving power should usually be considered with respect to a lens-film combination. The resolving power of a lens by itself indicates little as the final photographic product is necessarily a result of the combination.

The resolving power of a lens-film combination differs with variations in such factors as exposure, development, and subject contrast. Because of the effect of variables on the resolving power, the measurement is usually determined under strictly controlled conditions. Many different test patterns have been used by the photographic industry to determine resolving power, and the Air Force closely regulates its measurement in determining lens quality. At the present time the ratings of resolving power are given in terms of the lines-per-millimeter that can be distinguished.

The resolving power, as obtained for a given focus position at the various angles out to the corners of the sensitized material, is weighted by the percentage of the area of the zone, in which they occur, of the total area of the picture. This system of rating resolving power is known by the term "area weighted average resolution." The point that is most important photographically is not only the maximum resolving power, but whether the resolving power is ample over the entire format and over the range of densities or tones that are to be recorded when making the negative.

Definition. The term "photographic definition" refers to the quality aspect of a photograph that is associated with the clarity of detail. Since photographic definition is impression made on the mind of an observer when he views a photograph, the concept of definition becomes subjective and depends on the viewer. Definition is a composite effect of at least four factors:

- Resolving power.
- Sharpness.
- Graininess.
- Tone reproduction.

Exercises (238):

1. Define resolving power and briefly describe how it is calculated.

2. Define definition and briefly describe how it is determined.

4-6. Coating

How the front surface of a lens is chemically coated will affect its ability to resolve fine detail. Different manufacturers proudly herald how their lenses are coated to improve performance. So you should be aware of this idea.

239. Describe the purpose of a lens coating and the proper cleaning procedures necessary to preserve the coating.

For many years, it had been known that old lenses which had become tarnished with a bluish coating actually transmitted more light than new lenses. It is now common practice to coat lenses with a layer or layers of special coating that minimize internal reflections, thereby reducing optical flare (reflections off the glass surfaces of the lens) and improving transmission. By examining the front of a lens you will notice a slight color tinge (blue, yellow, etc.); this is caused by the lens coating used by the particular manufacturer.

Proper cleaning procedures should be observed to insure that this lens coating is not rubbed off. To clean a lens, first brush the surface with a fine brush to remove any foreign particles, then gently wipe the surface with a soft cloth or photographic lens tissue (not lens tissue for eyeglasses or wiping your

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nose), moistened with a recommended lens cleaner. The lens can then be "polished" with a chamois. The key throughout the cleaning procedure is to avoid undue pressure or a hard rubbing action along the surface of the lens.

Exercises (239):

1. What is the purpose of coating a lens?

2. How should you clean a lens to prevent destruction of the lens coating?

4-7. Normal Focal Length Lens

Today, the photographer has a tremendous number of lenses to choose from to achieve the results he wants. Yet every camera comes with a "normal" lens.

240. Indentify the rule for calculating the focal length of a normal lens.

The normal lens is considered to have a focal length that is about equal to the diagonal dimension of the film being used. The angle of coverage of a normal lens is approximately 45°. Normal lenses are usually the "fastest" lenses that are available and are therefore used for available light work. For the following standard film sizes, the following focal lengths are considered "normal."

Film Size	*Normal Focal Length*
35mm	50mm
120 (producing 2 1/4 X 2 1/4 image)	80 mm
120 (producing 2 1/4 X 2 3/4 image)	90mm
4 X 5	150mm
8 X 10	300mm

Exercise (240):

1. What is the rule for calculating the focal length of a normal lens?

4-8. Wide Angle Lens

The wide angle lens has a shorter-than-normal focal length. That is, the focal length is less than the diagonal dimension of the film that is being used. Wide angle lenses have characteristics which you should be aware of.

241. Complete statements about characteristics associated with the wide angle lens.

One of the main advantages of the wide angle lens is that it covers a wider subject area than that covered by a normal focal length lens at a given lens-to-subject distance. Typically, wide angle lenses cover from about 60° up to 180° for so-called "fisheye" lenses. This feature makes a wide angle lens the choice when you have a short lens-to-subject distance and you want to include as much of the subject as possible in the picture. Another advantage is that a wide angle lens has greater depth of field than the normal lens when both are used at the same lens-to-subject distance and aperture. This feature has made the wide angle lens a favorite of many photojournalists. They stop down their wide angle lens to a moderate aperture (for instance, f/11) to insure adequate depth of field at the average lens-to-subject distance they are using. Then they rely on depth of field ("zone focus") for sharpness rather than focusing each shot during fast moving events.

The advantages of the wide angle also create some problems to be considered. The wide angle coverage often produces a challenge to compose all of the picture elements effectively. Many beginning photographers choose a wide angle lens because they can get more in their pictures. This often leads to compositions that are confusing because of an absence of a strong point of interest. This is particularly true since the relative subject size is smaller as compared to a longer focal length lens at the same shooting distance. In addition, the wide angle creates distortions resulting in elongation or curving of lines that may not be pleasing. Also, because of the complex nature of many wide angle designs, the lenses tend to be sharper in the center than at the edges. This necessitates stopping down the lens a couple of f/stops to insure better sharpness.

Taking everything into consideration, the wide angle lens can be very effective when shooting in cramped quarters, when covering fast breaking news events, when photographing scenics, and for obtaining an overall shot of the scene (establishing shot).

Exercise (241):

1. Complete the following statements on the characteristics of wide angle lenses.
   a. Wide angle lenses have ______ than normal focal lengths.
   b. At a given lens-to-subject distance, the subject will appear ______ when using a wide angle lens than one with a longer focal length.
   c. At a given aperture and lens-to-subject distance, you will obtain more ______ ______ ______ when using a wide angle lens than when using a normal lens.
   d. Generally speaking, wide angle lenses are sharper in the ______ than at the ______.

4-9. Long-Focal-Length Lenses

Now that you have become familiar with normal and wide angle lenses, you will learn about long-focal-length lenses.

242. Give selected characteristics of long-focal-length lenses.

Long focal length refers to any lens that has a focal length greater than normal (i.e., greater than the diagonal dimension of the film) and relies on this fact to produce a large image size. Such lenses do not have to be of special design but are often the result of taking a lens designed for a larger camera and using it on camera having smaller film size. For example, you may be using a 4 x 5 press camera that is normally equipped with a 150mm lens. If this lens were replaced by a 300mm lens used on an 8 x 10 camera, the 300mm lens would be a long-focal-length lens on the 4 x 5 camera. (It is pointed out in the next section that a telephoto lens achieves the long-focal-length effect through special design.)

The advantage of a long-focal-length lens is like a telescope, that it has a narrower angle of coverage (about 35° or narrower), and produces a larger image size than a normal lens at the same lens-to-subject distance. This makes the lens ideal for portraits, sports, photography, and nature photography. Such a long-reaching lens makes it easier for the beginner to isolate his subject to achieve better composition.

There are disadvantages to using a long-focal-length lens. One problem is that unless the lens was designed for the camera that is being used, it may be difficult to attach properly. The size and weight of the lens may change the balance of the camera and require proper tripod support. Rigidity is further required because camera-movement is magnified by this type of lens. Long-focal-length lenses are slow and require using high speed film or supplementary lights. Finally, the depth of field of a long-focal-length lens is inherently less at a given aperture than a normal or wide angle lens at the same lens-to-subject distances. This problem is compounded by the fact that fast shutter speeds needed to prevent camera shake preclude small apertures.

NOTE: Long-focal-length lenses are primarily applicable to view and press cameras that use bellows for focusing and lens boards to interchange lenses. These features permit the interchange of lenses designed for different film formats which does not apply to small cameras.

Exercises (242):

1. How would you define a long-focal-length lens?

2. Why is it easier to achieve better composition with the long-focal-length lens as compared with shorter lenses?

3. Why do you need to use high shutter speeds when photographing with a long-focal-length lens?

4-10. Telephoto Lenses

Though the terms telephoto and long focal length have been used interchangeably, the term telephoto is properly applied only to lenses that have a particular optical design. Telephoto lenses have become the standard for long-reaching lenses designed for the small roll film cameras which you will be using.

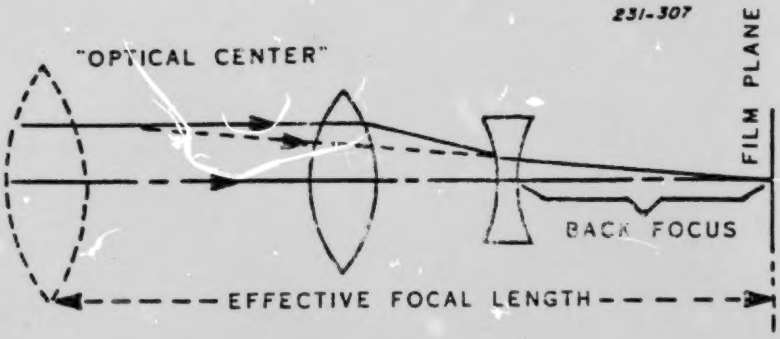

Figure 4-7. Basic telephoto lens design.

243. Identify correct and incorrect statements about characteristics that apply to telephoto lenses.

A telephoto lens gives a larger image than does the conventional lens at the same lens-to-subject distance. This is achieved by using a combination of increased focal length and a negative rear element spaced some distance away from the positive-image forming element. This type of design "pushes" the optical (not physical) center of the lens forward so that it is in front of the positive image forming element. This enables the lens to have an effective focal length that is longer than its actual physical length (see fig. 4-7). Due to the shorter length, the telephoto lenses are lighter and less bulkier than their traditional long-focal-length counterparts which depended on focal length alone. The telephoto type is therefore ideal for small cameras.

The advantages and disadvantages of using a telephoto lens are similar to those of the long-focal-length lenses. A telephoto produces a greater image size and a narrower angle of field than normal lenses. Telephoto lenses are therefore invaluable for sports, nature studies, and individual portraits. Their limited depth of field and narrower angle aid in composition by emphasizing the main subject. Their long reach permits the photographer to work farther away and this is important with many live subjects. The main disadvantages are that they are seldom fast and they emphasize any kind of camera shake. (A good rule of thumb is that you should use a shutter speed approximately equal to the length of the lens. If the lens is 100mm, then use a shutter speed of 1/125; if the lens is 500mm, then use a shutter speed of 1/500.)

Exercise (243):

1. Identify each of the following statements concerning telephoto lenses as true or false.
   a. The telephoto lens achieves its photographic affect by using a special optical design.
   b. Telephoto lenses are more convenient to use than long-focal-length lenses.
   c. It is more difficult to emphasize the subject when using a telephoto lens than when using a wide-angle lens.
   d. When using a 250mm lens, your shutter speed should be about 1/250.
   e. Telephoto lenses are more suitable for available light work than normal lenses.

4-11. Image Size Control

As a photographer, you need to carefully consider the relative size of your subject and other picture elements. Not only is this an important aspect of composition, but it is also a vital element throughout the reproduction cycle.

244. Describe the two photographic controls that are used to determine image size.

Given a particular film format, two factors that control image size are focal length of the lens and the lens-to-subject distance. The longer the focal length, the larger the image on the film for a given lens-to-subject distance. Therefore, by using a camera with an interchangeable lens capability and by having a selection of lenses, the photographer can control image size for any given shooting distance. Conversely, for any given focal *length of lens the closer you are to the* subject, the bigger the image will be. (Unfortunately, many lenses will not focus closer than a couple of feet from the subject.) The photographer should, therefore, always balance between shooting distance and focal length to achieve the results he wants.

Exercise (244):

1. Identify and describe the two controls that can be used to determine image size.

4-12. Perspective

You can see objects in three dimensions, but a lens forms images in only two dimensions (height and width). The missing dimension, depth, is suggested by the relative position and size of the objects in the image. Foreground objects are large, and background objects appear smaller. The relation of these objects, called perspective, is of considerable importance because it controls the naturalness of the picture.

245. Explain techniques related to photographic perspective and solve a problem related to center of perspective.

What determines the perspective in a photograph? The answer may surprise you. Once the photographer chooses the camera position in relation to the subject, the *relative* size and position of the objects within the scene are fixed. Nothing can change them. Notice that we have stressed the word, relative, because by changing focal lengths we can change image sizes but not the relationship of one subject element to another. Perspective is therefore completely controlled by camera position. One assumption has been made. It is assumed that the resultant photograph will be viewed at the correct viewing distance, that is, at the center of perspective.

What is the correct viewing distance or center of perspective for a photograph? It is a distance equal to the focal length of the taking lens for contact prints. It is a distance equal to the focal length of the taking lens times the number of diameters of enlargement when viewing projection prints. This is easier to understand if we use examples. Let us assume that an 8- x 10-inch contact print, made from a negative taken with a 13-inch lens, is being viewed. The correct viewing distance would be 13 inches. This distance closely approximates normal reading distance. Now assume that a 4- x 5-inch contact print is to be viewed. The lens used was 6 inches long. The eye now would have to be 6 inches away for proper perspective. This distance, however, is much too close for the average person; and as a result, the perspective may appear distorted. To achieve the proper perspective, the photographer should make an 8- x 10-print which would be about a two-diameter enlargement and would extend the viewing distance to 12 inches.

Exercises (245):

1. What technique controls perspective and why?

2. Why doesn't the selection of lens focal length control perspective?

3. If you had a 4- x 5-inch negative that had been taken with a 4-inch lens, what standard size print should be made if the audience will view the picture from a distance of 18 inches?

4-13. Depth of Field and Focus

Depth of field and depth of focus are interrelated optical factors which affect the sharpness of your photographic images. Both of these concepts are important and, in particular, depth of field should be considered with every photograph you take. Prior to understanding these two concepts, you need to understand circle of confusion.

246. Explain the relationship between circles of confusion and critical focus.

Circles of Confusion. For a basis of discussion, think of every subject as being composed of individual points, each reflecting

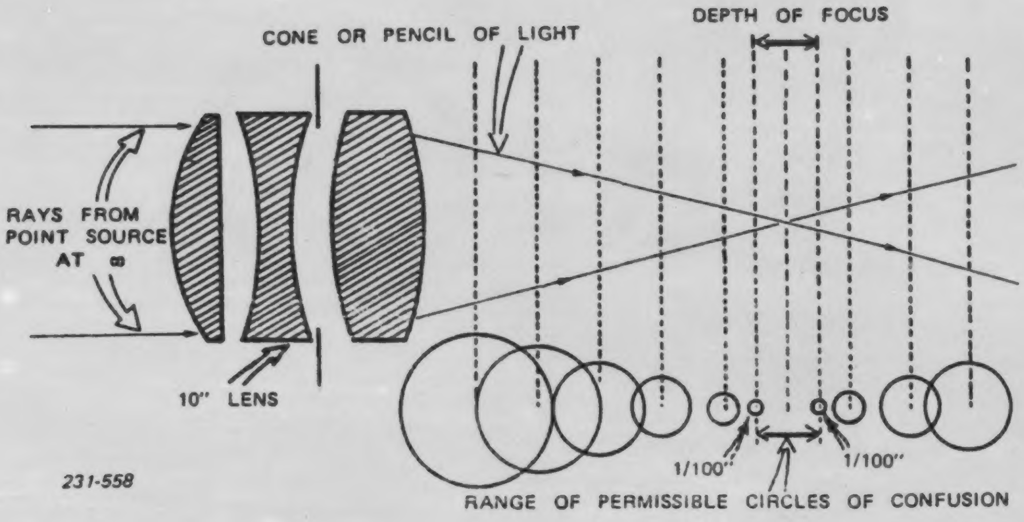
CONE OR PENCIL OF LIGHT
DEPTH OF FOCUS
RAYS FROM POINT SOURCE AT ∞
10" LENS
231-558
1/100"
1/100"
RANGE OF PERMISSIBLE CIRCLES OF CONFUSION

Figure 4-8. Circles of confusion.

light. The photographic lens collects the rays of light coming from these points, refracts them, and then brings them to points of focus on the focal plane or ground glass.

The focal plane is defined as the surface on which an image transmitted by a lens is brought into sharpest focus. It is the surface occupied by the light-sensitive film in the camera. It is also the plane occupied by the ground glass of a view or press camera. A lens is unable to bring light rays to a perfect point on the image plane. Instead, the image of the point is actually a small circle of light. These images of individual subject points are termed "circles of confusion." If the actual measurement of the circles of confusion shows to be one one-hundreth of an inch or smaller and they are viewed from a distance of approximately 12 inches, they appear to the human eye to be points. If they are viewed at a closer distance than this, these circles must be smaller. If they are viewed at a greater distance, the circles may be proportionally large and still appear as single points. When the image is focused so that the circles of confusion are the smallest possible for the lens, the image is said to be in critical focus.

Figure 4-8 demonstrates how the light from a point source at infinity distance forms a cone of light behind the lens which converges to a point and then diverges to form another cone. If the cone were to be intersected or cut through by a ground glass at the various planes shown, the image on the ground glass would illustrate the various circles of confusion. Going from left to right in the figure, let us study the image of the point. At the plane closest to the lens, the cone of light would be nearly as large as the lens. If you move the ground glass farther from the lens, the size of the circles become relatively smaller until the size is within the permissible limits for circles of confusion. As you move still farther back, the image of the point continues to get smaller until the minimum circle of confusion is reached. This is the point of best focus for the lens, and the diameter of the circle of confusion is the smallest possible for that particular lens. If you move the ground glass farther back, beyond the point of best focus, the circle gets larger until once again the maximum permissible circle of confusion is reached. Beyond this region, the circles continue to get larger until, again, the image is out of the range of acceptable focus.

The usable, or permissible, circles of confusion should not have diameters greater than 1/2000 of the focal length of the lens when negatives are being made for 2 to 4 diameter enlargements. If negatives are being made for contact printing only, a permissible circle of confusion having a diameter no larger than 1/1000 of the focal length is acceptable.

Exercise (246):

1. Explain the relationship between circles of confusion and critical focus.

247. Define depth of field and list and explain factors necessary to control depth of field.

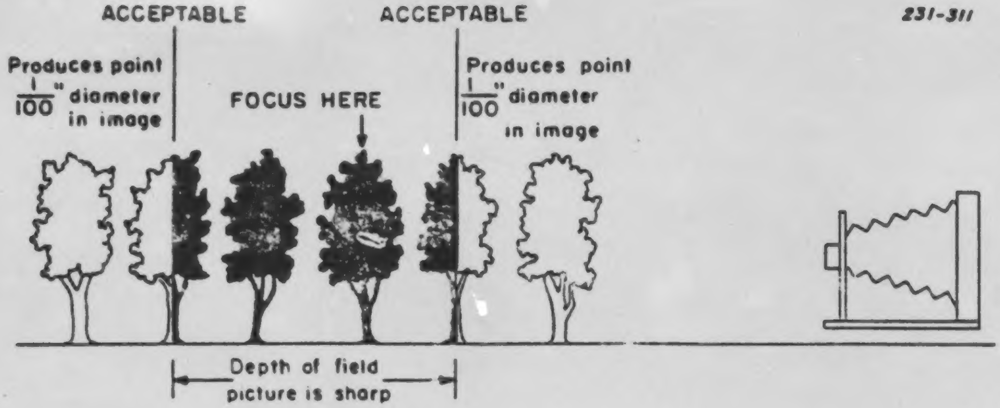
ACCEPTABLE
ACCEPTABLE
231-311
Produces point $\frac{1}{100}$" diameter in image
FOCUS HERE
Produces point $\frac{1}{100}$" diameter in image
Depth of field picture is sharp

Figure 4-9. Depth-of-field.

Depth of Field. When taking a photograph, you can critically focus only on a single plane. Subject areas in front of or beyond this plane will be increasingly blurred. Or to put it another way, the circles of confusion are the smallest at the point of critical focus and are increasingly larger for other parts of the subject. The range over which areas of the image appear acceptably sharp or over which the circles of confusion remain small enough to appear as points is called the depth of field. To put into the standard definition: depth of field is the distance from the nearest plane in acceptable focus to the farthest plane in acceptable focus. This definition is illustrated in figure 4-9.

The implication of depth of field is very important because practically all photographic subjects, except flat copy subjects, are in more than one plane and therefore have depth. It is very important for the photographer to be able to control and calculate what parts of the subject will appear sharp to the viewer.

The following factors within the control of the photographer all influence depth of field.

- Focal length. Other factors remaining constant, the shorter the focal length of the lens, the greater the depth of field (see fig. 4-10).
- Lens to subject distance. Other factors remaining constant, the farther the object is from the lens, the greater the depth of field.
- The aperture (diaphragm). Other factors remaining constant, the smaller the f/stop setting, the greater the depth of field (see fig. 4-11). (It should be emphasized, however, that

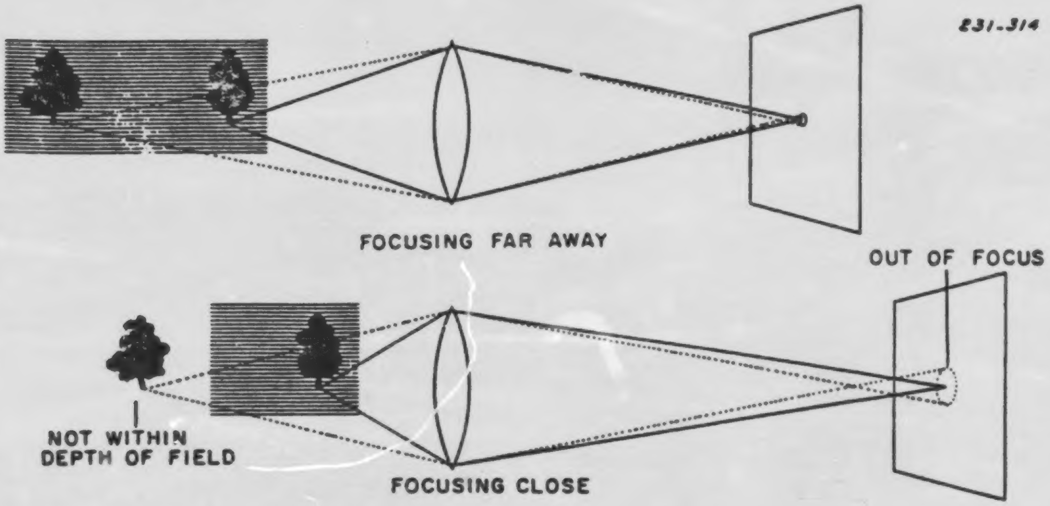

Figure 4-10. Focal length determining depth-of-field.

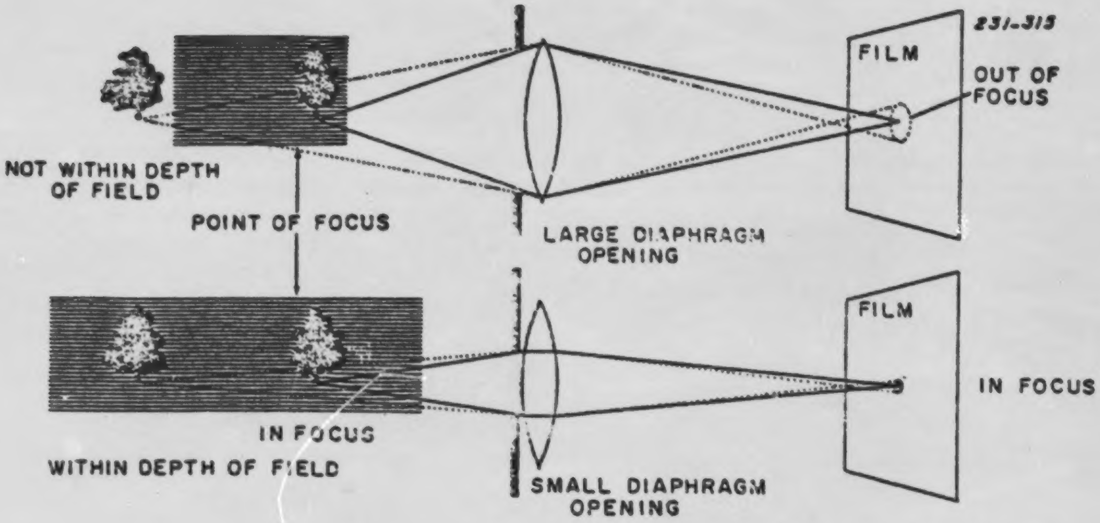

Figure 4-11. Diaphragm control of depth-of-field.

stopping down the diaphragm does not improve the sharpness of the point focused upon, but rather makes points to the front and rear sharper. In fact, due to the optical problem of diffraction, stopping down to the smallest aperture setting may actually cause an overall loss of image quality.)

To summarize by example, when you use a wide angle lens stopped down to f/16 to shoot a scenic, you will have great depth of field; but when you use a telephoto lens opened to f/2.8 to shoot a head and shoulder portrait, you will have very little depth of field. It is therefore important to consider these factors every time you shoot. Depth of field can be a creative tool. A limited depth of field can make the subject stand out, while great depth of field can produce wide ranging detail. The choice is yours, but you should know what you are doing and why you are doing it.

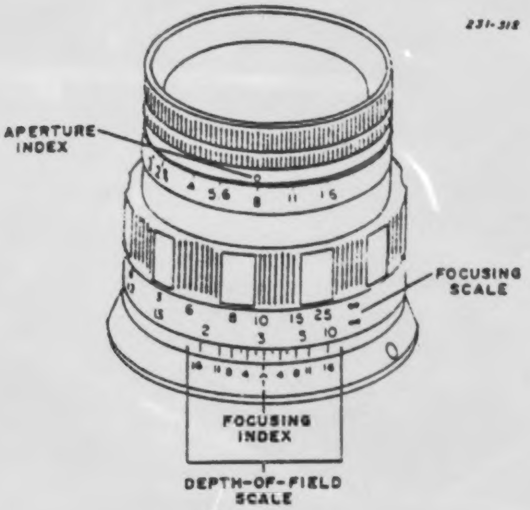

Figure 4-12. Depth-of-field scale.

The actual depth of field for any given shooting situation can be measured. Lens manufacturers produce depth of field tables that tell you the exact area covered by a given lens, lens to subject distance, and f/stop combination. Also, depth of field scales are engraved on many lenses. Figure 4-12 illustrates a lens that provides a depth of field scale. To calculate the depth of field for a given focusing distance (10 feet in the illustration) and a given aperture (f/8), refer to the numbers on either side of the focusing index that relate to the aperture being used and then read the distance opposite the f/stop number. For example, in the illustration, reading up from f/8 on each side gives a distance (using the foot scale) of from 8 to 15 feet. Also, many single lens reflex cameras have a depth of field

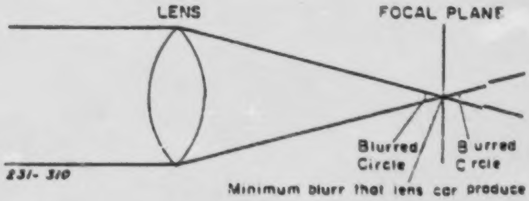

Figure 4-13. Depth-of-focus.

preview button which when depressed shows the image at the taking aperture. This gives you a rough visual idea of what areas will appear sharp.

Exercises (247):

1. Define depth of field.

2. List and explain the three factors the photographer can use to control depth of field.

248. Define depth of focus and list and explain the factors that affect depth of focus.

Depth of Focus. Depth of focus is measured at the film plane and not at the subject. It sets the tolerable limits of lens-film plane distance. In other words, depth of focus is the distance in front of and behind the film plane that will be in acceptable focus. Like depth of field, depth of focus increases as the aperture is stopped down. Unlike depth of field, depth of focus increases as focal length increases, and increases as subject distance decreases. Depth of focus is a concern of the manufacturer, but it is a good idea to keep in mind when using a view camera where the film plane is moved about and in doing critical closeup work where precise focusing is essential. Review figure 4-8 and study figure 4-13.

Exercises (248):

1. Define depth of focus.

2. List and explain how the three factors that affect depth of field affect depth of focus.

4-14. 2/5th Rule

The 2/5ths rule is a good one to learn while you are trying to apply the principles of depth of field.

249. Calculate the area of sharpness in front of a hypothetical subject by applying the 2/5ths rule.

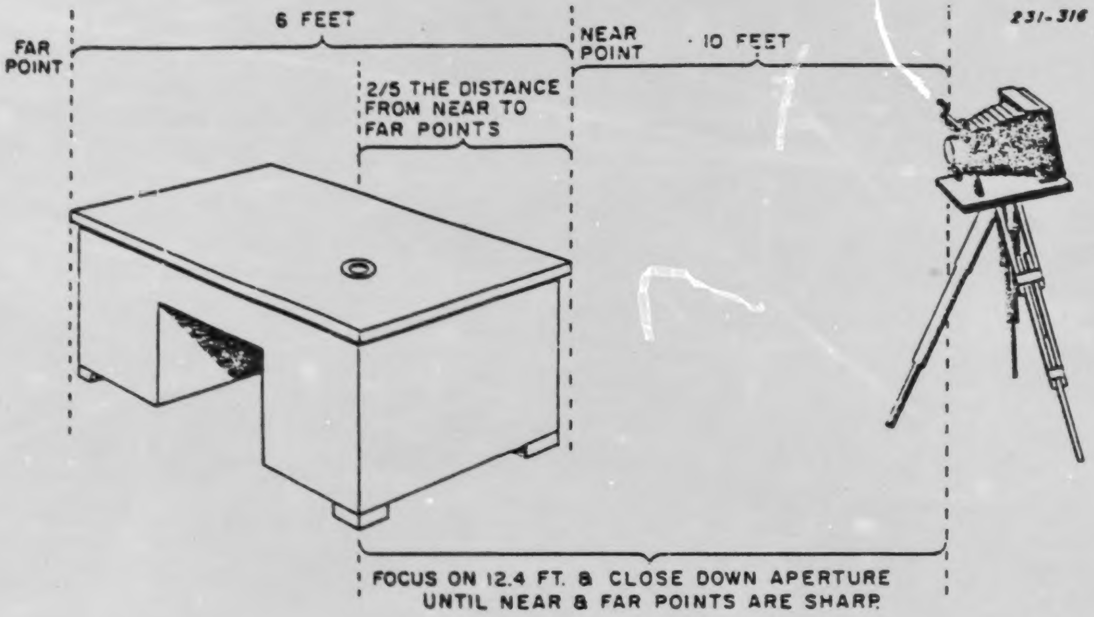
6 FEET
FAR POINT
NEAR POINT
10 FEET
231-316
2/5 THE DISTANCE FROM NEAR TO FAR POINTS
FOCUS ON 12.4 FT. & CLOSE DOWN APERTURE UNTIL NEAR & FAR POINTS ARE SHARP

Figure 4-14. The 2/5th rule.

The 2/5ths rule is a generalization that states: When a plane is focused upon, for each 2 feet in front of that plane that is in acceptable focus, 3 feet behind that plane will be in acceptable focus. The first step in applying this rule is to determine the nearest and the farthest points you wish to include in your depth of field. When this has been calculated, divide this total distance into fifths. Then, focus upon a plane, or subject point 2/5ths of the distance beyond the nearest acceptable plane. After this, stop down the diaphragm until the nearest and farthest planes come into acceptably sharp focus. (This procedure works with camera that have ground glass focusing. If you are using a rangefinder camera, you will have to rely on your depth of field scale.) Study figure 4-14 to see how this works.

The 2/5ths rule is exact only for the average scene (near the hyperfocal distance), but for all practical purposes it can be applied for any distance where the subject is greater than 6 feet from the lens. As the point focused upon comes closer to the lens, the 2-to-5 ratio gradually approaches equality until at 2 focal lengths between the lens and the subject, the ratio becomes 1:1.

NOTE: Hyperfocal distance. The term "hyperfocal distance" refers to the distance from the lens to the nearest plane in acceptable focus when the lens is focused on an object at infinity. The hyperfocal distance varies with aperture, focal length, and permissible circle of confusion. Everything from the hyperfocal point to infinity is in acceptable focus; everything from the hyperfocal point to the lens is beyond the limits of acceptability. The easiest way to set a lens for the hyperfocal distance is to set the infinity mark of the focusing scale opposite the selected f/stop engraved on the far side of the depth of field scale. This insures that the depth of field will cover from the nearest possible point to infinity. This is the way to maximize depth of field for a given aperture/focal length combination.

Exercise (249):

1. Assume you are photographing a subject that is 12 feet from the lens. You calculate that a distance from the subject to 6 feet beyond is acceptably sharp. Apply the 2/5ths rule and calculate the zone of acceptable sharpness starting with the subject and going towards the camera.

4-15. Critical Aperture

To get the best results possible from your lenses, you should know the critical aperture for each one.

250. Define critical aperture.

Physical limitations in the design of lenses make it impossible to manufacture a lens of uniform quality and performance from its center to its edges when used at all focusing distances and all possible apertures. Therefore, to obtain the best quality with most lenses, many manufacturers recommend eliminating the use of the lens edge by decreasing the diaphragm opening about two stops from the largest aperture. This or any other aperture that transmits the sharpest image is considered the critical aperture.

You should test each lens in your camera system and determine the critical aperture for each one. The critical aperture varies from type to type, brand to brand, and even within lenses with the same brand and description. By knowing how each of your lenses perform, you will be able to bring home the sharpest results.

Exercise (250):

1. Define critical aperture.

4-16. Flare

There are two general types of flare: mechanical and optical. Because they can reduce the sharpness of your images, you should know how each type can be eliminated.

251. Briefly explain the two types of flare and tell how they can be reduced or eliminated.

Mechanical Flare. Mechanical flare is caused by reflections that occur because of reflective surfaces on the inner side of the lens barrel, the camera, or anywhere else near the lens. Normally, mechanical flare is not an inherent characteristic of the lens, but it is the result of a damaged or burnished surface. Instead of being absorbed, light coming from the subject strikes such surfaces and is reflected onto the film.

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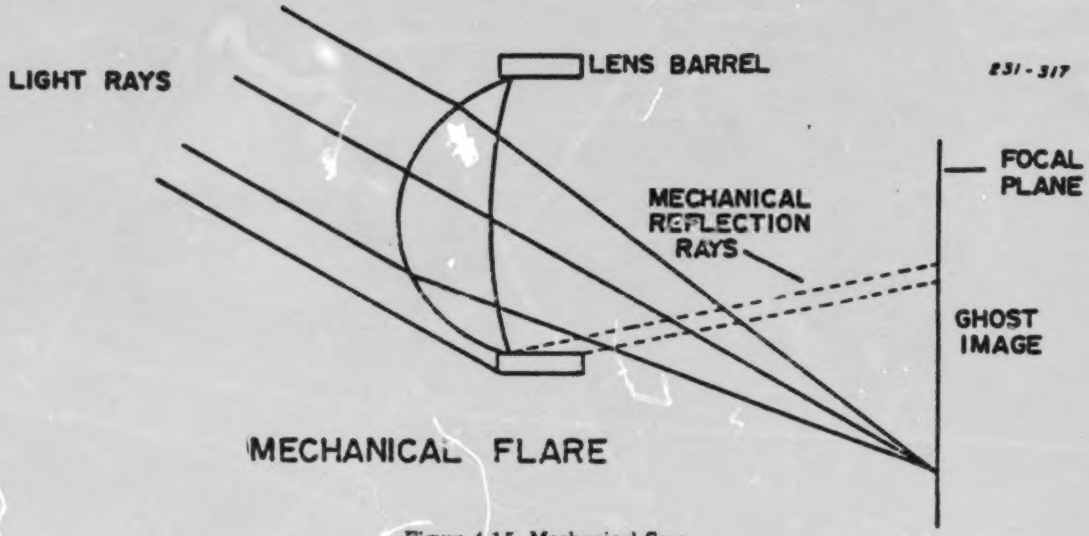

Figure 4-15. Mechanical flare.

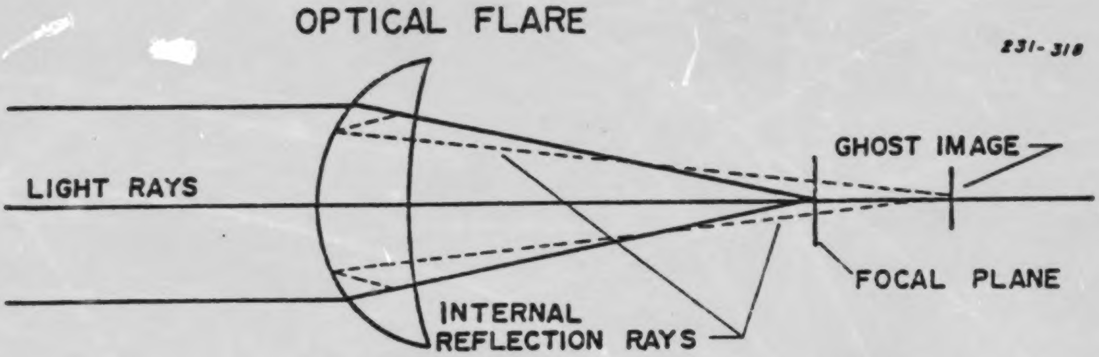

Figure 4-16. Optical flare.

This flare can be eliminated by coating damaged surfaces with a nonreflective coating (see fig. 4-15).

Optical Flare. Optical flare is caused by internal reflections from the glass-to-air surfaces of the lens. Optical flare is present to some extent in any lens having more than one element. Generally speaking, because of the greater number of glass-to-air surfaces, the more complex the lens, the greater the amount of optical flare. The problem of optical flare has been greatly reduced by coating lenses. The photographer can also help himself by always using a lens shade and not pointing the camera directly into the sun (see fig. 4-16).

Exercises (251):

1. Briefly explain how mechanical flare is caused and how it can be corrected.

2. Briefly explain how optical flare is caused and how it can be corrected.

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Available and Supplemental Light

PHOTOGRAPHY is the recording of an image on a light-sensitive material by the action of light. Chemicals are used to make the image visible. Because light is necessary to photography, you should know quite a bit about its properties, characteristics, and pecularities. Also, you should understand what the various sources of illumination are, how the light that is emitted from various sources differs, and how the light can be controlled by using different devices and techniques.

Light must be used as a tool of photography. Learning how to use light to your advantage will help you produce more desirable results. Using light as it is may be satisfactory for a record photograph, but better results can be obtained if you fit the lighting to what you want to say in a photograph. In other words, lighting should fit the picture. Since there are so many possibilities, this is no simple task. When you become the master of light and lighting techniques, you will find that you have mastered one of the great variables of the photographic art.

5-1. Theory of Light

The recording of light is what photography is all about. Therefore, as a photographer, you must have a thorough understanding of light in order to achieve the best possible photographic results.

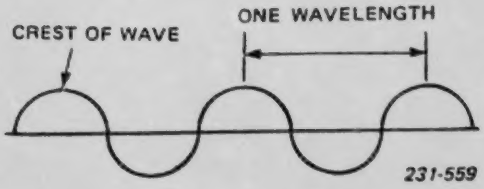

Figure 5-1. Wavelength.

252. State principles and characteristics that apply to light and its application to photography.

Light is a form of wave energy that radiates in all directions from its source. It is only one type of many similar forms of wave energy. Others include radio waves, infrared, ultra-violet, X-rays, and gamma radiations. A simple example of wave motion can be demonstrated by dropping a pebble into a pool of water. As the pebble hits the water, it causes waves to spread in expanding circles until they hit the edge of the pool. Light waves from the sun travel in much the same manner. However, the waves in the pool are very slow and clumsy in comparison with light waves, which travel approximately 186,000 miles per second in air.

Different forms of radiant energy are distinguished from each other in two ways. They differ in wavelength and frequency. Wavelength is the distance from the crest of one wave to the crest of the next (see fig. 5-1). Frequency is the number of waves that pass a given point in one second. The product of frequency and wavelength determine the speed of travel for a given form of radiant energy.

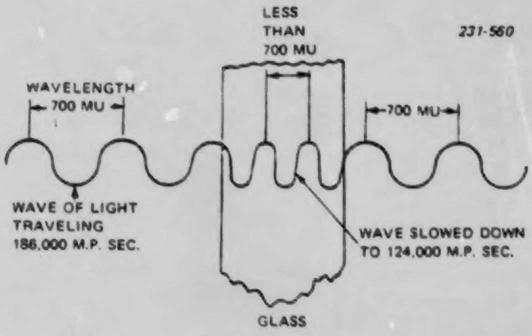
LESS THAN 700 MU
231-560
WAVELENGTH
700 MU
700 MU
WAVE OF LIGHT TRAVELING 186,000 M.P. SEC.
WAVE SLOWED DOWN TO 124,000 M.P. SEC.
GLASS

Figure 5-2. Speed of light in different mediums.

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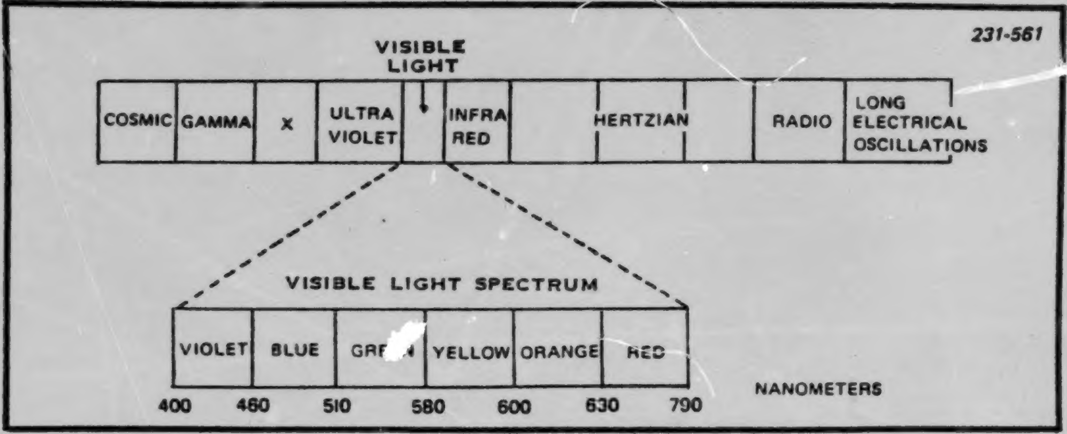

Figure 5-3. Electromagnetic spectrum.

The speed of light is constant for any given medium, but varies as it enters a medium of different density. For example, the speed of light in ordinary glass is only about two-thirds of its speed in air. Since the frequency of light is a constant, the change in speed must be a result of a change in wavelength. If frequency remains constant, it would appear logical to use this as a means of identifying the different types of radiant energy. However, in some instances, it is extremely difficult to measure frequency accurately. For example, the frequency of violet light is roughly 176 trillion waves per second. For this reason, any particular type of radiant energy is usually identified by its wavelength in air (see fig. 5-2).

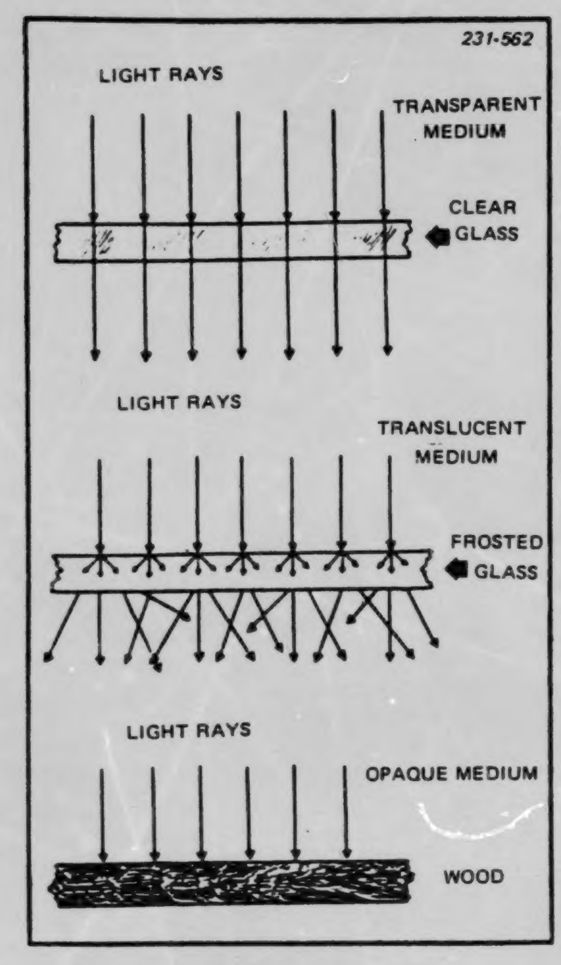

Figure 5-4. Transmission of light.

The various forms of radiant energy form a continuous series of wavelengths, each differing from the adjacent wavelength by an extremely small amount. This grouping of wavelengths is known as the electromagnetic spectrum. However, only a small portion of this spectrum is used to take photographs (see fig. 5-3).

Ultraviolet, infrared, and the visible portion of the spectrum are a group of wavelengths that conform to the laws of optics. This means that these wavelengths can be bent by an optical device such as a lens. This group of wavelengths forms the *optical spectrum.* Some forms of radiation, such as X-rays and gamma rays, do not conform to the optical spectrum and can penetrate cameras and film containers to produce unwanted exposure of sensitized materials. This undesirable exposure is called fog. The photographer should be aware of the presence of these radiations and take precautions to protect his sensitized materials from damage.

What, then, is light? In photographic terms, light is that part of the electromagnetic

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spectrum that stimulates the sensory organs in the eye and produces the sensation of vision. For this reason, these wavelengths form the *visible spectrum*. However, there are other portions of the electromagnetic spectrum that affect the photographic process. Under certain conditions, other radiations not visible to the eye may be recorded. Infrared and ultraviolet radiations are specific examples of radiations that cannot be seen and yet may be recorded photographically.

Visible light occupies a portion of the spectrum that extends from about 400 to 700 nanometers (nm). As you can see in figure 5-3, there is a definite relationship between color and wavelength of the visible radiations in the electromagnetic spectrum. The shortest wavelengths, around 400 nm, would appear violet, while the longest wavelengths, about 700 nm, would appear red. In between, light appears blue, green, yellow, or orange depending on the wavelength of the particular radiation. The photographic process relies heavily on this color quality of light.

Exercises (252):

1. Light is what type of energy?

2. What are the two ways to measure radiant energy?

3. Speed of radiant energy is a product of what factors?

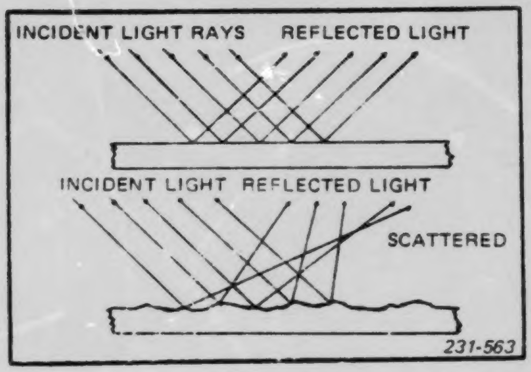

Figure 5-5. Specular and diffused reflections.

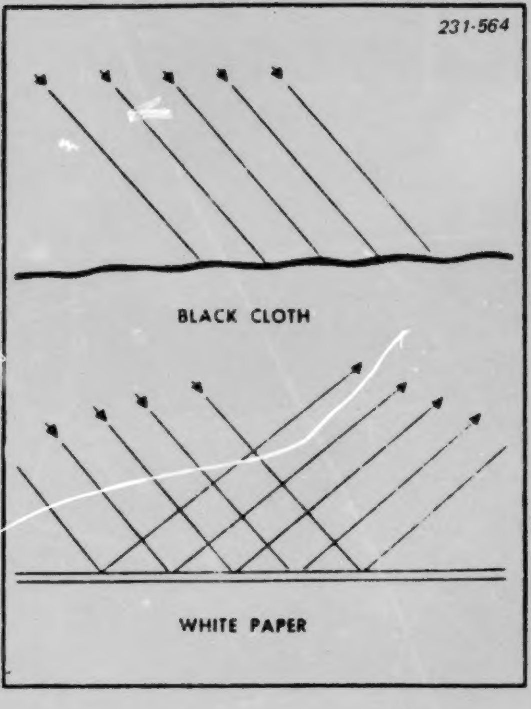

Figure 5-6. Absorption and reflection of light.

4. How are different forms of radiant energy identified?

5. What is the optical spectrum?

6. What color are the shortest wavelengths of visible light?

7. Long wavelengths of visible light form what color?

253. Define terms used to explain how light behaves.

When light is incident (strikes) upon a surface it is either transmitted, reflected or absorbed, or a combination of these depending upon the type of surface. Light, of

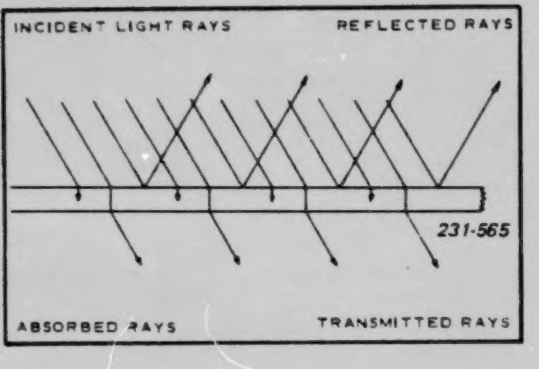

Figure 5-7. Light is reflected, transmitted, and absorbed.

course, will pass through any type of clear material like glass. If the surface is very dense, like frosted glass or plastic, the medium is translucent and light is diffused as it passes through it. If the medium is neither transparent nor translucent, it is opaque, meaning that it does not transmit light, (see fig. 5-4).

Light can be reflected or thrown back from the surface of the medium. If the surface of the medium is smooth and polished, the reflected light is thrown back in the same plane and at the same angle as the incident light, and the reflection in such cases is said to be *specular.* If the surface of the medium is rough, the reflected light is diffused, (see fig. 5-5). It is this light which is of the greatest value to photography. Most objects reflect both specular and diffused light. Rough surfaces reflect more diffused light than specular, and smooth surfaces usually reflect more specular light than diffused.

If light is neither transmitted nor reflected, it is absorbed by a medium. Dark objects, for example black cloth and dark earth, absorb more light than lighter objects, such as a white sheet of paper or a white slab of concrete or limestone, (see fig. 5-6). When light is incident upon a medium, some absorption and reflection always take place. No medium completely transmits, reflects, or absorbs all of the light incident upon its surface. Figure 5-7 shows how glass not only transmits, but also absorbs and reflects light.

Another important property of light is that it can be bent or change its direction. This bending of light is called *refraction.* In figure 5-8, you can see that as light goes from one medium to another of different density, its direction of travel is changed. If the ray of light strikes the glass perpendicularly, it passes straight through with no change of direction. This is called a *normal* ray. If, however, the light enters the glass obliquely, it is bent or refracted. In order to picture how this bending takes place, imagine the light traveling in a flat front with point A (fig. 5-8) entering the glass first. This part, as it enters the glass, is slowed down causing the direction to change to the right, in much the same manner as the wheels of a car are turned to the right when the right wheel runs onto a soft shoulder. In figure 5-8, you can see that the ray continues in its changed direction until it comes to the outer edge where point A′ of the ray emerges first and speeds up, causing the ray to swing back to the left. The explanation of this action has been resolved into the Law of Refraction, which states: "If light enters a medium of different density at an oblique angle, its direction is changed so that the ray of light is bent toward the normal if the medium is more dense, or away from the normal if the medium is less dense." The law of refraction is illustrated in figure 5-9. It is this property of light that makes it possible for a lens to form an image. Light can be bent and directed by shaping the surfaces of the medium into planes that are not parallel (as in

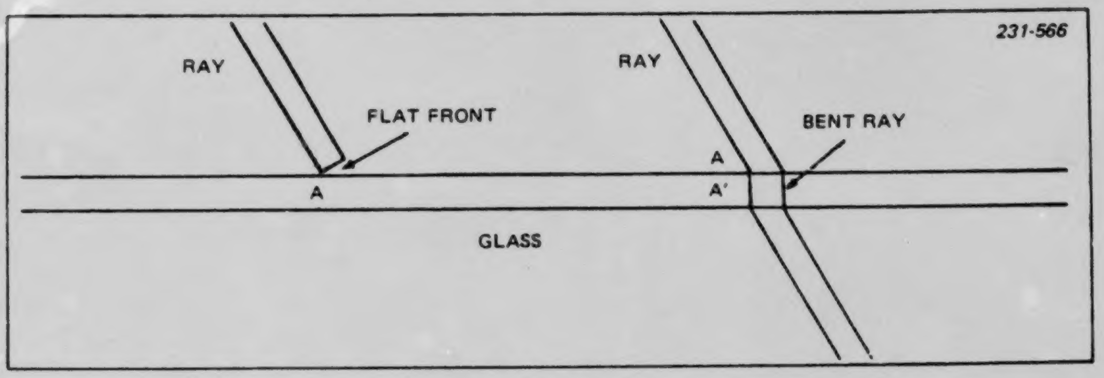

Figure 5-8. Oblique ray of light.

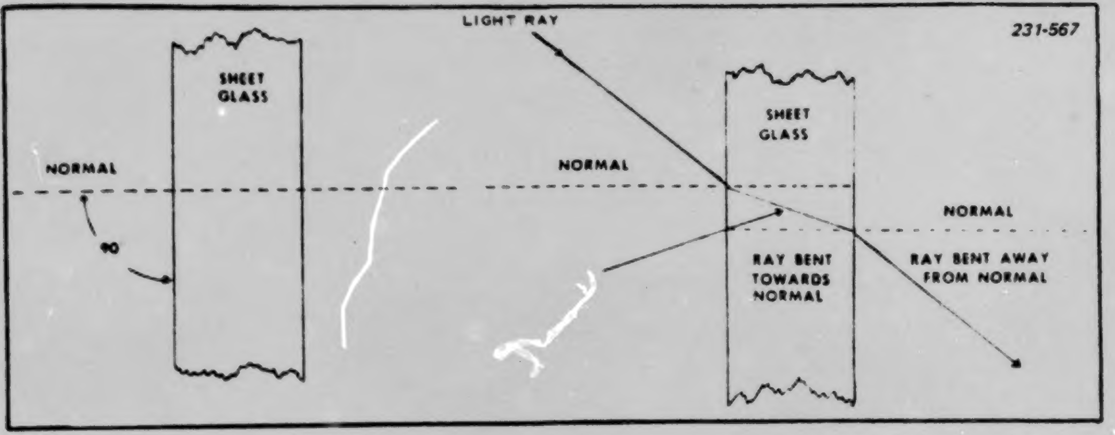

Figure 5-9. Law of refraction.

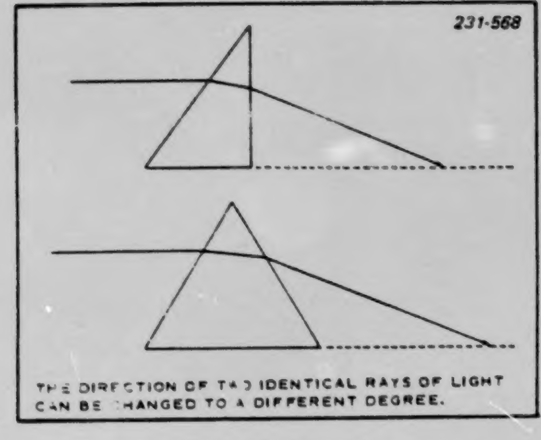
231-568
THE DIRECTION OF TWO IDENTICAL RAYS OF LIGHT CAN BE CHANGED TO A DIFFERENT DEGREE.

Figure 5-10. Controlled bending of light.

a prism) to control the bending of the light to a desired degree. Figure 5-10 shows how two identical rays of light can be controlled in this manner.

White light is a mixture of all colors and each color has its own particular wavelength in air. When white light is refracted, all of its colors or wavelengths are not refracted to the same degree. Some colors are refracted more than others, depending upon the wavelength. The shorter the wavelength of a color, the more it is refracted. This means that when white light is passed through a prism, as in figure 5-11, the various colors that compose the light are separated or dispersed. Dispersion presents a difficult problem in making lenses.

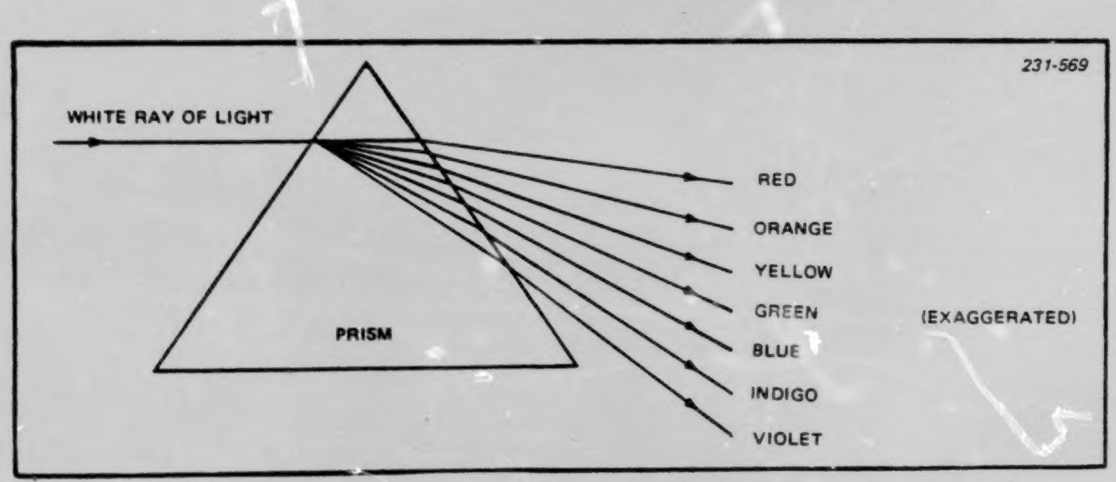

Figure 5-11. Dispersion of light.

The color of an object is determined by the manner in which it reflects and absorbs light. If an object reflects all of the wavelengths of white light, it appears white. If white light is incident upon an object that reflects only the red waves, absorbing most of the others, the object appears red. Yellow is the result of most of the blue of white light being absorbed and the mixture of red and green being reflected. Magenta is the result of the green being absorbed and red and blue being reflected. In other words, the color of an object is due to the mixture of the colors of light that are reflected, transmitted, or absorbed.

Another factor that you must take into consideration when studying the colors of light is the *brightness* of a color. Most people see yellow as the brightest color and violet as a very dark color. Green, red, and blue fall between these two extremes. Each color will reflect different amounts of light due to its brightness. In black and white photography, it is this brightness value which is translated to different shades of gray.

Exercise (253):

1. Define the following terms as they relate to light.
   a. Transmission.

   b. Translucent medium.

   c. Specular reflection.

   d. Color.

   e. Brightness.

   f. Normal ray.

   g. Dispersion.

   h. Law of refraction.

5-2. Daylight

Light is considered as coming from two sources: natural and artificial. Natural lighting comes from the sun, stars, or reflectance of light off the moon. All other light is the product of artificial sources (ex. tungsten light bulb). Daylight is the most common natural lighting source in photography. Knowledge of daylight is, therefore, essential to the accomplishment of the majority of outside missions.

254. Identify as correct and incorrect principles about daylight lighting.

Daylight is composed of direct sunlight diffused through the aerosol which comprises the earth's atmosphere, the light reflected from the sky, and the light reflected from objects on the earth's surface. The nature of daylight at any given time is dependent upon geographic location, the time of day, the season of the year, and the prevailing weather conditions. (Weather accounts for the greatest variation in daylight.) When there is a minimum of atmospheric haze, the amount of direct sunlight is maximum—about 80 percent of the total light. A slightly cloudy sky can reduce the intensity of direct sunlight by about one-third. A completely overcast sky reduces both the sky light and the direct sunlight, the former to about 50 percent, and the latter to about 25 percent of their intensity on a clear day.

The spectral energy distribution, rated as color temperature Kelvin (K) of the sun's rays, changes as the angle of the sun changes with relation to the horizon. At dawn and during the late afternoon before sunset, the dust and vapor particles in the atmosphere tend to scatter the shorter, blue wavelengths of light more than the longer, red wavelengths. Thus, morning and evening light is red in color.

As the sun approaches its zenith, the blue wavelengths of light have less reflection and absorption by the atmospheric particles, and the sky appears blue. At the same time, the direct rays of sunlight have less atmospheric haze to penetrate and are therefore more intense. Of course, as the sun passes its zenith, its light becomes less intense. Typical observations are shown in table 5-1.

The values represented in tables of this sort are for one geographic location only and are therefore not necessarily valid for other locations. The accepted standard is 5400K for

TABLE 5-1

COLOR TEMPERATURES (L) FOR SUNLIGHT AND DAYLIGHT CONDITIONS AT VARIOUS TIMES OF THE DAY THROUGHOUT THE YEAR

231-578 Light Conditions and Time of Day	Apr., May	June, July	Sept. Oct.	Nov., Dec., Feb.
Direct Sunlight Only:				
0900 to 1500	5800	5800	5450	5500
Before 0900 and After 1500	5400	5600	4900	5000
Daylight: Sunlight and Clear Sky:				
0900 to 1500	6500	6500	6100	6200
Before 0900 and After 1500	6100	6200	5900	5700
Sunlight and Slightly Hazy Sky	5900	5800	5900	5700
Sunlight and 25% to 75% Overcast	6450	6700	6250	—
Completely Overcast Sky	6700	6950	6750	—
Hazy or Smoky Sky	7500	8150	8400	7700
Clear Blue Sky Only:				
0900 to 1500	26,000	14,000	12,000	12,000
Clear Blue Sky Only:				
Before 0900 and After 1500	27,000	—	—	12,000

mean noon summer sunlight at Washington, D.C. After consideration of all variables, photographic daylight averages 5500K. While these standards hold true only for the location where they were taken or somewhere near the same parallel of latitude, they are useful for purposes of comparison. Artificial sources of light can be made to conform to a desired daylight level, and the color response of film can be controlled so that photographic results can be predicted.

The prevailing weather condition is a most important factor in determining how the daylight affects our subject. Let us, therefore, discuss the effects of several common conditions.

- Bright sunny day. A bright sunny day is not always the best for photography. Because the bright sun casts dark shadows that lack detail, while the highlights are extremely bright, the lighting produces high contrast. To lower the contrast a photographer may need to use supplementary artificial light.

- Bright hazy day. Haze, smog, or thin layers of clouds cause the sunlight to be diffused, therefore the contrast is less and the shadows are not as detailess as on a bright sunny day.

- Dull overcast day. This produces very low contrast as the difference between the highlights and shadows is not very great. This type of lighting can produce very flat pictures which are good for detail but may not have enough punch for some tastes.

Exercise (254):

1. Identify each of the following statements related to daylight lighting as true or false.
   a. Daylight is only composed of direct sunlight and the light reflected from sky.
   b. Weather is the biggest variable in daylight conditions.
   c. The Kelvin rating of daylight changes with the angle of the sun.
   d. A hazy June day sky has a color value of about 8150K.
   e. As the sun approaches its zenith the short wavelengths of light are absorbed.
   f. Contrast is greater on a bright hazy day than on a sunny day.

5-3. Electronic Flash

Electronic flash has become the most popular type of artificial light source. Electronic flash units are used on cameras as well as in large studio units. It is therefore a very important type of lighting system to understand.

255. List advantages and clarify specified characteristics and procedures related to electronic flash operation.

Electronic flash is a repeating source of photographic light. A flash tube which may be fired many thousands of times is used in place of conventional flash bulbs. The flash tube is fired with power provided by batteries which are located within the unit or carried in

TABLE 5-2
ELECTRONIC FLASH GUIDE NUMBERS

Film Speed	Power Setting			
	1/4	1/2	3/4	Full
10	27	37	45	53
25	41	59	72	83
32	45	66	81	94
40	53	74	91	105
50	59	83	102	118
60	65	91	110	130
80	74	105	130	150
100	83	120	140	165
150	100	140	180	200
200	115	165	200	235
300	140	200	250	290
400	165	235	300	345
500	190	270	350	400

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a pack. Flash units designed for camera use are light, convenient, and quite powerful.

Aside from the convenience and portability of electronic flash, it has many advantages which make it the ideal light source for all around professional use. Its extremely short flash duration is not only useful for photographing action, but for minimizing general camera and subject movement. The flash is a very penetrating light with ability to record shadow detail without blocking up highlights. It is especially suitable for portraits, since it eliminates the need for hot, glaring lights that cause squinting, wrinkles, and self-consciousness. Because its extremely brief flash has no effect on the subject's eyes, it eliminates contraction of the iris, resulting in the larger pupils which add character to your portraits. The flash is extremely rich in blue (i.e., high Kelvin values) which make it suitable for daylight color films and all black and white materials.

Each electronic flash has a guide number or numbers (guide numbers are used to calculate the aperture setting and will be discussed in detail in a later section) based on the output of the unit in relation to the speed of the film being used. This output may vary if different power settings are available. Table 5-2 lists a series of guide numbers for different power outputs for a typical professional unit in relationship with the film speed (ASA) being used.

TABLE 5-3
POWER SETTINGS FOR ELECTRONIC FLASH

231-580

FLASH DURATION	1/4	1/2	3/4	Full
	1/1200 sec.	1/800 sec.	1/600 sec.	1/500 sec.

No shutter speeds are listed in electronic flash guide number charts because of the short duration of the flash, which may be used effectively as the exposure time. The approximate flash duration for each of the power settings in our previous table are shown in table 5-3.

Although electronic flash shutter speeds are not usually essential to exposure calculation, using the fastest practicable speed for the power setting chosen lessens the possibility of obtaining "ghost images" from any existing illumination on the subject. For example: The unit is set at 1/4 power, giving a flash duration of 1/1200 of a second, but a shutter speed of 1/30 of a second is used. The flash is short enough to "freeze" normal subject movement, but since the shutter is open so much longer, unless the shooting area is darkened, subject movement may register during this time because of existing illumination. This results in ghost images.

Exercises (255):

1. What are three advantages in using electronic flash with your camera?

2. Why is electronic flash particularly suitable for portraits?

3. How are guide numbers calculated for electronic flash units?

4. What will cause a ghost image?

256. Define flash synchronization and compare two methods of synchronization.

"X" Synchronization. To be effective the flash must go off at the moment the shutter is open. This is accomplished through synchronization whereby the shutter mechanism is designed to complete the electrical circuit of the flash at the proper time.

The synchronization of electronic flash is extremely simple. The duration of the flash is so short compared to the average shutter speed that no delay is involved between trigger and flash. Synchronization is achieved by triggering the electronic-flash unit at the time the shutter blades reach their wide-open position. This normally is accomplished by placing "X" contacts in the shutter which close at the time the shutter is wide open. Leads from these contacts go to the exterior of the shutter and terminate at an electrical terminal. A "synch" cord designed to connect this shutter terminal with the electronic flash unit completes the circuit which triggers the unit.

With leaf shutters synchronization is quite easy and the photographer may choose any shutter speed that he wants to use. The reason for this is that when the shutter is tripped, the leaves of the shutter open and close in unison. However, focal plane shutters, which are found, for example, in almost all 35mm cameras, require special consideration. The focal plane shutter, which consists of a curtain controlled aperture moving in front of the film, causes each portion of the film to be exposed for a specified time. However, the time required to expose the complete film format greatly exceeds exposure time for each portion at high shutter speeds.

To produce an even exposure across the entire format, the flash must maintain its peak throughout the total exposure time. For example, when using a 35mm reflex camera at a slow shutter speed like 1/60 of a second the focal plane shutter aperture opens up to cover the entire film format of approximately 1½ inches and remains open throughout the exposure. This produces the necessary exposure over the entire film format. However, if the shutter speed is changed to 1/250 of a second the shutter aperture is reduced to a mere sliver which travels across the film format exposing a sliver of film at a time. Though each part of the film receives only 1/250 of a second of exposure, it still takes about 1/60 of a second for the shutter to travel the entire width of the film. This is why the majority of 35mm focal plane shutter cameras require that you use a shutter speed of 1/60 of a second. Remember, that at too slow a shutter speed ghost images result, and at too high a shutter speed only a narrow band gets properly exposed.

Exercises (256):

1. What is flash synchronization?

2. Why is it easier to synchronize electronic flash with a leaf shutter than a focal plane shutter?

257. Give selected definitions, procedures, and advantages related to different ways of using electronic flash.

Using Electronic Flash. Electronic flash is a very versatile supplementary light. Let us see how it can be applied in a number of ways.

On camera flash. The flash unit may be directly attached to the camera. The flash is directed straight into the subject. Particularly when used indoors this technique often produces very flat lighting of the subject with very harsh background shadows. This problem can be reduced if the flash bracket is designed to hold the flash head high above the camera.

Bounce lighting. Bounce lighting approximates the effects of natural lighting. Rather than aiming the flash directly at the subject, the flash head is tilted or aimed so light is reflected or bounced off a ceiling, wall, or reflector. More natural, subtle tones result through the use of bounce lighting which diffuses the light. This technique is therefore preferred over direct flash.

Open flash photography. This is non-synchronized flash photography. First you open the shutter (using T or B), discharge the flash, and then close the shutter. Open flash photography requires that the camera be on a tripod. Using open flash you can "paint" your subject with light. Just work in a dark room with a subject that is stationary. Go about the subject discharging your flash unit. This technique can duplicate results obtained with multilight setups. One point: keep yourself out of the view of the camera.

Multiple electronic flash/single power unit. Multiple electronic flash may be accomplished by using two or more lamp heads with one power unit and cables designed for this purpose. The total light output is the same as from a single unit, but it is divided among the multiple heads. If each unit is placed at the same distance from the subject and at approximately the same angle from the camera-subject axis, the basic guide number should be used. If the lamp heads are

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positioned at unequal distances and angles from the subject, the guide number should be calculated for the lamp head nearest to the subject. Multiple lighting permits lighting large subjects and permits proper control of highlights and shadows.

Multiple electronic flash/multiple power units. Multiple light with electronic flash is easily accomplished using "Slave Units" instead of extensions. This gives the advantage of not being tied down to a number of cords. Each lamp used in this system is usually equipped with its own power pack. Therefore, each unit receives full benefit of whichever power setting you choose to use. Exposures are computed from the shortest lamp-to-subject distance or from the head producing the strongest illumination on the subject. Two or three units are usually sufficient for average photographic work. The system should be tested before starting to shoot, to make sure all lamps are firing properly. A photocell picks up the light from the flash synchronized to the camera and "fires" the lamp to which it is attached. Wiring is not required between slave units and the camera. There is no synchronization problem, since the reaction of the electronic flash is almost instantaneous.

Exercises (257):

1. Why is bounce lighting preferred over direct flash?

2. How is open flash photography accomplished?

3. What is a slave unit and in what kind of setup is it used?

5-4. Incandescent Lighting

Probably the most common source of so-called artificial light is radiant emission from hot materials. The torch, the candle, the oil lamp, the gas mantle lamp, and finally the incandescent electric light bulb trace man's progress in producing useful and controllable artificial light. All are incandescent; that is, they are sources of heat or thermal radiation. All emit infrared radiation as well as visible light, and display increased efficiency with increased temperature. Photofloods and flashlamps (i.e. flashbulbs) are a photographer's primary incandescent light sources.

258. Complete statements about characteristics of photographic incandescent light sources.

High-Efficiency Photographic Lamps. This source of light produces continuous illumination instead of the peak of a flashbulb. The light is produced by the passage of an electrical current through a wire filament. Enough current must flow to heat the filament sufficiently for it to glow and emit light. The common household lightbulb uses 115-volt alternating current, available in practically any building. While household lightbulbs can be used for photographic purposes, they usually have insufficient output. Therefore, high efficiency lamps have been designed specifically for photographic purposes. The filament is heated to a higher temperature than the common lightbulb, causing an increased light output. Lamps of this type are often referred to as photoflood lamps.

The greatest advantage of the high-efficiency photographic lamp is that it enables a powerful light source to be squeezed into a small glass envelope. Lamps of this type are generally used in reflectors so that the illumination may be directed to the most appropriate area. The smaller lamps may very easily be used in regular household fixtures in place of the standard light source. Using them in this manner has the effect of raising the general level of light in the room while still retaining a natural-looking effect. Remember, however, high-efficiency lamps produce considerable heat.

High-efficiency photographic lamps are also supplied in an envelope with a built-in spot or a flood reflector. The advantage here is convenience, since no other reflector is needed. By simply screwing the lamp into an ordinary socket fastened to an extension cord, you have a spot or flood lamp. As with most incandescent lamps, the high-efficiency lamp has a high red content, and therefore is best suited for panchromatic film. Also, the high-efficiency lamp has a much shorter life than a conventional household bulb.

Flashbulbs. Flashbulbs are metal-based glass containers formed into shapes very much

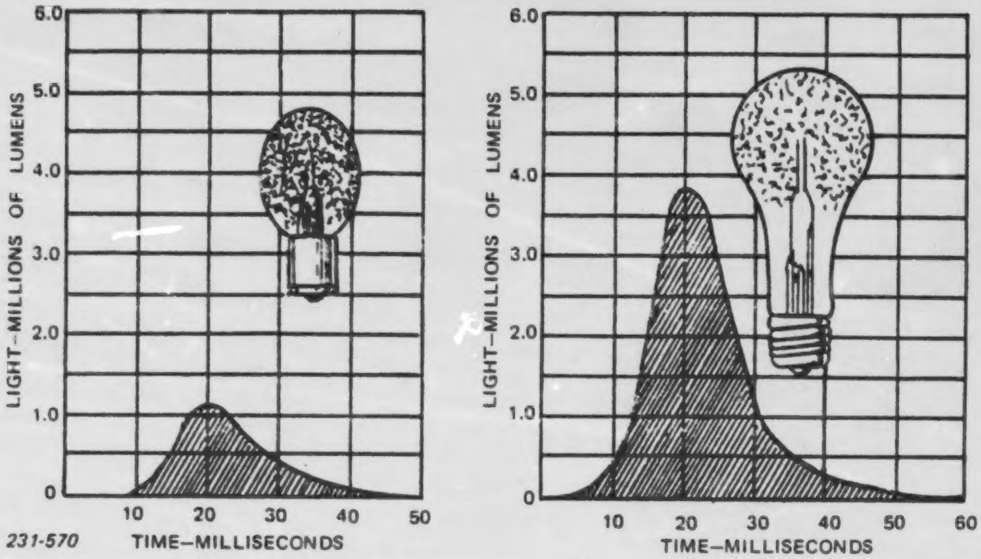

Figure 5-12. Photoflash lamps.

the same as those used for common lightbulbs. The clear glass envelope is filled with a highly combustible combination of oxygen and a hair-fine alloy wire. When a flashbulb is ignited by electrical current flowing through a filament, a primer material is fired and starts the wire in the envelope burning. The wire burns brilliantly in the oxygen atmosphere for a very short period of time measured in fractions of a second. Illumination of the subject is provided by the combustion of the fine wire.

Flashbulbs come in a number of different sizes. The smaller lamps produce less illumination; but since they are convenient they are extremely popular with persons who must do a great deal of flash photography. Lamps with a greater light output are necessarily larger in size and extremely useful when large areas are being photographed and high light output is needed (see fig. 5-12).

Exercise (258):

1. Complete the following statements regarding the characteristics of incandescent light source.
   a. Photofloods, unlike flashlamps, produce __________ illumination.
   b. Household lamps are rarely used for photographic purposes because they have __________ __________ .
   c. Photoflood lamps, like most incandescent sources, are rich in __________ light.
   d. Flashbulbs provide illumination through the combustion of a __________ __________ ________________ .

259. Give definitions, procedures, and purposes related to techniques of using incandescent light sources.

Incandescent light sources continue to be popular for studio and engineering work. Flashbulbs for field use have been largely supplanted by electronic flash which is easier, safer, faster, and cheaper to use. Nevertheless, you may be called upon to use flashbulbs. Let us, therefore, discuss a couple of common operational situations using incandescent lights.

NOTE: Techniques that are applicable to electronic flash, except for the use of slave units, are applicable to incandescent lights. Conversely, techniques we will be discussing are also applicable to electronic flash.

Synchronizing Flashbulbs. One point you have to learn in using flashbulbs is that the majority of bulbs require "M" rather than

"X" synchronization like electronic flash. Different synchronization is called for because flashbulbs require about 20 milliseconds to reach maximum brilliance while the average leaf shutter takes about 5 milliseconds to reach the fully open position. Therefore, when the shutter button is depressed the shutter must be delayed about 15 milliseconds so the flash can reach its peak. If you use "X" synchronization when you are supposed to use "M," you will have image cutoff.

NOTE: There are a variety of flashbulbs including types designated for focal plane shutters. Check with both your camera and flashbulb instructions for correct synchronization and shutter speed selection for best performance.

Synchro-Sunlight Photography. When you take photographs in bright light, dark shadows result. This may be very undesirable when taking a photograph because the subject's eye sockets are often quite dark and a shadow may obscure part of the face. The same problem arises when full detail may be obscured by shadows. With a flashbulb, you can add detail in shadow areas without affecting the natural appearance of your subject.

The correct ratio of light intensity between highlight and shadow areas varies for different types of subjects. (This ratio is called a lighting ratio.) For example, a 4:1 ratio provides a good balance between highlights and shadows and also gives the impression of depth in a photograph. To obtain the correct balance between daylight and flashbulb, you should place the flash unit at the correct distance from the subject. The following is the procedure you should follow:

(1) Using a photoelectric exposure meter, compute the correct exposure for the highlight area of the subject. Assume this to be 1/125 at f/16.

(2) Find the guide number (guide numbers are discussed in detail in the next section but for now, consider them as an indicator of flash power) for the flashbulb, film, and shutter speed being used. Assume the guide number to be 160.

(3) Divide the guide number by the daylight f/stop. In our example, this would be 160 divided by 16, which equals 10.

(4) For these conditions, you would then use a flashbulb-to-subject distance of about 10 feet.

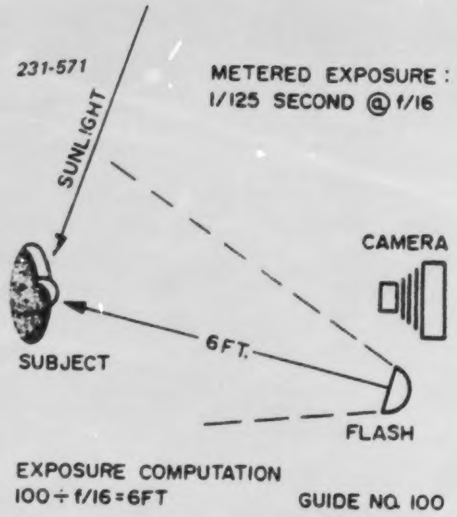

Figure 5-13. Synchro sunlight flash.

In the above procedure, placing the flashbulb at a distance of 10 feet should give a balanced 1-to-1 lighting ratio between the sunlight and the flashlamp. However, the ratio is actually 4-to-1, because the flashbulb loses about three-fourths of its effect out of doors. (This reduction in strength is caused because there is no reflection of light. The same would happen in a large enclosure like an auditorium.) If you want a 2-to-1 ratio, reduce the computed lamp-to-subject distance by one-third. For a 1-to-1 ratio, reduce the distance by one-half. Refer to figure 5-13 for a graphical representation of computing lamp-to-subject distance to obtain a 4-to-1 lighting ratio between the sunlight and the flash.

Using Photofloods. Lighting arrangements when using high-efficiency lamps are essentially the same as arrangements used with single or multiple flash. You may use a single lamp at the camera position. Or, if you desire, you may move a single lamp to the side of the camera so that it casts shadows in a certain direction. To soften shadows, you may place a second lamp to the other side of the camera. The second lamp can be a lamp of lower light output, or you can move a lamp of the same intensity farther away from the subject than the first lamp. The second lamp acts as a fill-in light to reduce the shadows. You may use additional lamps to illuminate a background, highlight a person's hair, or shoulder line. In other words, you can light the subject as you wish.

Exercises (259):

1. Why is "M" synchronization needed for flashbulbs?

2. Briefly explain the term lighting ratio.

3. What is the purpose of synchro-sunlight photography?

4. Briefly explain the steps necessary to determine the distance the fill-in flash should be from the subject when you are shooting outdoors.

5. What is the usual purpose of the second light of a multilight setup?

5-5. Flash Guide Numbers

Exposure with flashbulbs or electronic flash units are based on two facts. First, a particular type of flashbulb, flashbulb reflector combination or electronic flash unit at a given power setting consistently produces the same amount of light. Second, as the distance between the subject and the light source increases, less and less light will fall on the subject. The amount of light falling on the subject is inversely proportional to the square of the distance from the lamp to the subject. These two calculations, along with the film speed being used—and in the case of flashbulbs, the shutter speed that is chosen—are the basis for calculating a particular exposure. In this section, we discuss guide numbers that are very helpful in calculating flash exposure.

260. With the aid of table 5-4, solve problems that involve the application of flash guide numbers.

TABLE 5-4
SAMPLE GUIDE NUMBER CHART

FOR ADJUSTABLE CAMERAS (Flashbulb in Polished Reflector)					
Film Speed (See Film Instruction Sheet)	Exposure Guide Numbers 231-581				
	Any Sync. Setting	M Sync Only			
	Up to 1/30	1/60	1/125	1/250	1/500
25	135	125	100	80	50
32-50	170	160	125	100	65
64-100	240	220	180	140	90
125-200	340	320	250	200	125
250-400	480	450	350	280	180
500-800	670	650	500	400	250

Guide Numbers. Primarily on the basis of the output of the flashbulb or electronic flash unit, manufacturers have worked out flash guide numbers which aid in calculating exposure. (Since we have briefly mentioned electronic flash guide numbers in section 5-3, we will now use flashbulb examples. The principles in using the guide numbers are the same.) For example, each type of flashbulb has a series of guide numbers that vary with shutter and film speed combinations.

Applying the guide number is easy. By dividing the flashbulb-to-subject distance into the appropriate guide number, you will find the f/stop you should use. On the other hand, if you have already decided on the f/stop you intend to use, divide the guide number by this f/stop to obtain the correct lamp-to-subject distance.

Let's illustrate the use of guide numbers in an actual situation. Table 5-4 gives the guide numbers for a typical flashbulb. (A chart similar to this is found on each carton of flashbulbs.) Assume that you are using a film with a tungsten exposure index in the 64-100 range. (Many black and white films have both daylight and tungsten speed ratings. This is necessary because a particular film may be more sensitive under blue rich daylight conditions than red rich tungsten conditions, etc.) You decide on a shutter speed of 1/125. For this combination, the chart shows a guide number of 180. Now suppose you want to make the exposure at a lamp-to-subect distance of 20 feet. You would then divide the guide number by the distance (180 ÷ 20) which would give you a setting of approximately f/8. If you had wanted to use a particular f/stop (ex. f/16), you would divide that into the guide number to get your lamp-to-subject distance (ex. 180 ÷ 16 would give you a lamp-to-subject distance of about 11 feet).

There are several factors which can modify your basic exposure calculations whether you are using flashbulbs or electronic flash. The following are a few points you should consider.

a. Guide numbers are based on units being used in an average size room having fairly

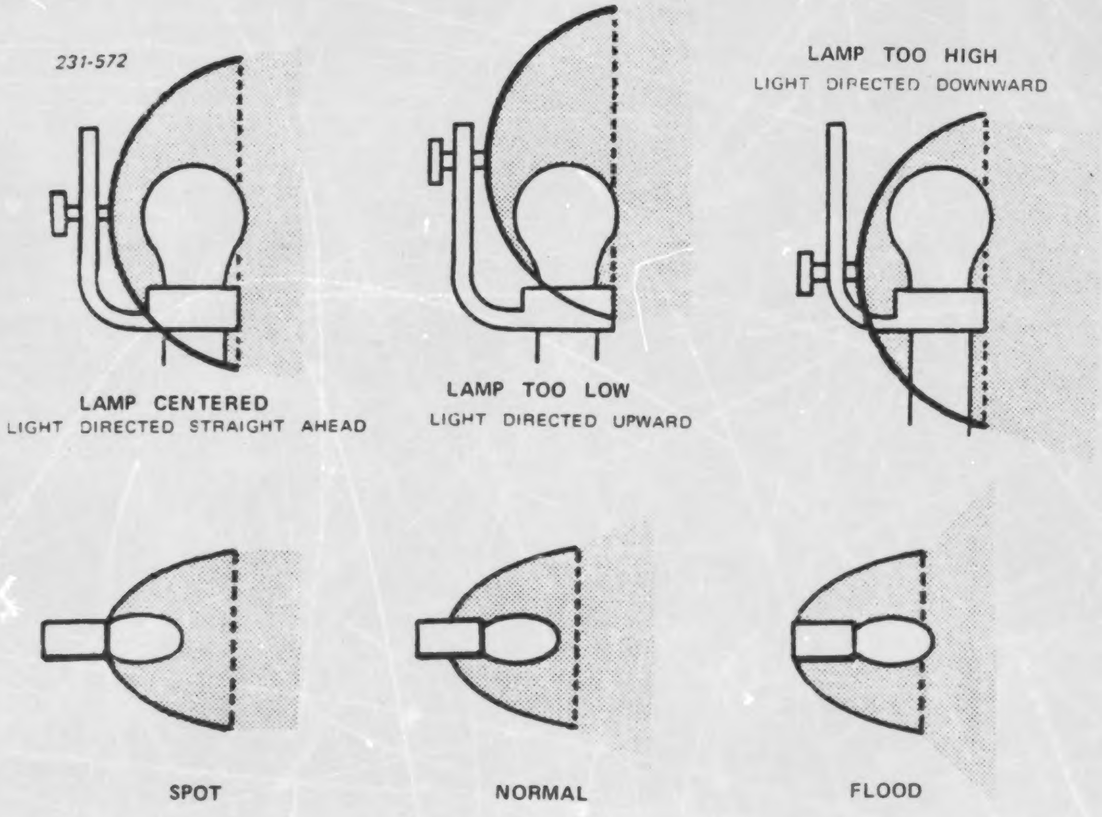

Figure 5-14. Reflector positioning.

light-colored walls and ceilings. When a flash is fired in a room, only 25 percent of the light from the unit goes directly to the subject. The rest of the light strikes the walls, ceilings, any flash reflector that is used, people, furniture, machinery, etc. The absence of such reflection, for example when you are shooting in a gymnasium or outdoors, would mean you would have to open up about two or more f/stops to prevent underexposure.

b. When using flashbulbs, the type of reflector that you use and the position of the bulb within the reflector will affect the direction of the light and its intensity on the subject. These two factors will of course affect your exposure, (see fig. 5-14). In fact for a very weak fill light some photographers don't use a reflector at all.

c. When using electronic flash you may use an umbrella to give a diffused light. Exposure will have to be increased depending on the umbrella's shape, size, color, and surface material.

d. When calculating the lamp-to-subject distance when using bounce flash, you must add together the distance from the lamphead to the reflecting surface and from the reflecting surface to the subject.

e. It is important to consider the reflecting surfaces you are working with. Dark colors absorb more light than light colors. Smooth surfaces reflect more than rough surfaces. High ceilings reflect less than low ceilings. So it is a good idea to make a series of photographs using different exposures to insure a satisfactory result.

NOTE: While we have been stressing black and white photography, it might be well to mention that light from a flash will take on the color of the reflecting surface. For example, if you are taking a color portrait using flash in a room with green walls, the subject could become bathed in green light which can give sickening skin tones.

The points we have just mentioned suggest that practice with your camera and flash unit under a variety of conditions is essential to developing competence and confidence.

CAUTION: For safety and mission success you must keep your flash units, synch cords, power packs, electrical power supplies, and cameras in top condition. Remember when you are working with flash you are working with electricity. Frayed wires, overloaded circuits, and corroded batteries can spell TROUBLE. Flashbulbs are a particular safety hazard as they can explode and cause glass to fly in all directions. Therefore, when using flashbulbs always have a shield over your reflector and don't carry the bulbs in your pockets. (Airmen have been severely hurt when bulbs they were carrying in their pockets were exploded by radar waves!)

Exercise (260):

1. Using table 5-4 as a source of guide numbers, solve the following problems.
   a. You are using film rated at ASA 125 with a shutter speed of 1/500. What aperture setting would you use at a lamp-to-subject distance of 10 feet?

   b. Your camera is loaded with ASA 25 film. Your exposure setting is f/11 at 1/60. What would be your lamp-to-subject distance?

   c. You are using film rated at 100 with a shutter speed of 1/250. Your lamp-to-subject distance is 13 feet. You have to open up two stops for a very dark colored room. What is your f/stop setting?

5-6. Quartz Iodine Lamps

Quartz iodine lamps have become increasingly popular for studio and copy lighting. Therefore, you should become familiar with this type of lighting.

261. Identify from a list of characteristics those belonging to quartz iodine lights.

It has been pointed out that all tungsten filaments are more efficient when working at high temperature. High temperatures cause rapid evaporation of the filament, so that in a conventionally constructed light bulb the lamp life is short. Research has shown that if a halogen such as iodine vapor is present in the lamp this combines with the evaporated tungsten, which is then attracted to the hottest local surface, the filament. The iodine thereby creates a regeneration cycle which increases filament life and eliminates bulb blackening.

The quartz-iodine (also called tungsten-halogen) lamps are compact, highly efficient for their size, and maintain constant color quality. They are available in a variety of sizes and color temperatures. They are quite common now in copy, studio, and motion picture work where they prove superior to other types of incandescent lighting.

Using the quartz-iodine lighting is similar to using photofloods or other types of continuous supplemental lighting. Exposure can be determined by the use of an exposure meter or by reference to manufacture published exposure guides. In a multiple lighting situation, you use the main light to calculate exposure.

One point to remember when working with quartz iodine lamps or any lighting system is safety. You must be sure that there is no overloading of circuits and that the lamps are handled correctly. One of the key safety hazards with quartz iodine lamps is their intense heat. They should be handled with special heat resistant gloves when in use. Wearing gloves helps prevent fingerprints from being left on the quartz tube. These prints can be etched into the glass because of the lamps' intense heat.

Exercise (261):

1. Which of the following lamp characteristics apply to the quartz iodine lamp?
   a. Cool burning.
   b. Synchronized to camera.
   c. High intensity.
   d. Long life.
   e. Should be handled with gloves.
   f. Constant color temperature.
   g. Intermittent light source.
   h. Suitable for copy work.

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Photographic Filters

FILTERS ARE used to control the light striking the film. By effectively using filters, you can change the relative contrast between colors. You can identify, subdue, or eliminate a color through the proper filter choice. Filters, when thoughtfully chosen, can help you to achieve better quality in your photographic work. In this chapter we cover the construction, types, and use of filters.

6-1. Construction

Filters are primarily of two kinds—dyed gelatin or colored glass. Let us discuss the advantages and care for both.

262. Describe specified characteristics of gelatin and glass filters.

Gelatin Filters. The simplest filter is a sheet of dyed gelatin that can be cut into pieces of the appropriate size and held in front of the lens by a suitable holder. Gelatin filters are cheap and are supplied in the widest variety of colors. Thus, they are very popular for experimentation, color photography, and for use with odd-size lenses. The main disadvantage of a gelatin filter is that it is delicate. Scratches, discolored spots, and fingerprints will render the filter useless.

Glass Filters. Glass filters are made out of dyed glass or by using a sheet of dyed gelatin between two sheets of glass. They come in a variety of sizes (designated in millimeters or series) and types. A glass filter may be either screwed into the front of the lens or held by a retaining ring (used for series filters). Glass filters are more expensive and durable than gelatin filters but do not come in quite the variety of colors and density ranges. Each glass filter should be treated just like a lens. Any lint or dust should be removed with a brush. Lens tissue moistened in lens cleaner should be used to remove fingerprints.

NOTE: All filters, regardless of the method of manufacture, fade with use. It is, therefore, a good idea to replace your filters at regular intervals.

Exercises (262):

1. What are two advantages of using gelatin filter?

2. What is the main advantage of a glass filter over a gelatin filter?

3. In time, what happens to any filter?

6-2. Effects and Limitations

The photographic filter is an optical device for controlling the transmission of light to the film. To understand the use of filters you apply what you know about the sensitivity of film and the color quality of light. Using filters is easy and will greatly enhance your photographic work. In this section you will learn what a filter does to light.

263. Identify the color, absorption, and transmission of different colored filters and for given conditions, identify likely problems in filter application.

White Light. White light or visible light is

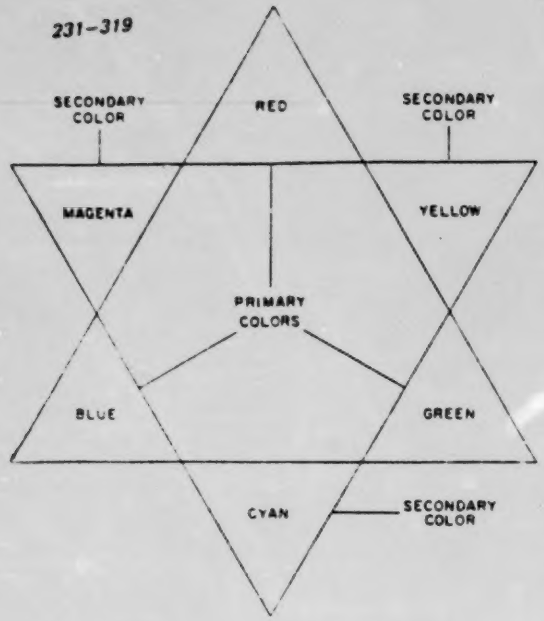

Figure 6-1. The color star.

composed of blue, green, and red wavelengths of light. These three colors are called the *primary colors* because none of these can be created by any combination of the other two. In addition, all three of these colors of light must be present to combine and create white light. If blue and green light are combined in equal quantities, they form cyan. A combination of blue and red light produces magenta, and green and red light combine to produce yellow. Cyan, magenta, and yellow are called *secondary colors.*

The color star in figure 6-1 shows the primary and secondary colors in a logical arrangement. Notice that each color in the star has a color directly opposite it. Colors on opposite sides of the color star are called *complementary colors.* When each of the complementary colors of light are mixed in the correct proportion, they also produce white light. Magenta and green are complementary and they can combine to form white light. Magenta is actually red and blue. When green is added, all three primary colors are present and white light is formed. In the same way, red and cyan are complementary, and blue and yellow are complementary. To repeat, red, green, and blue light combined in the correct proportions make white light.

Filter Application. By using a filter over a camera lens, we can employ what is known as *subtractive color filtration.* As this is explained, you should carefully study figure 6-2.

First, let us consider the effect produced when the primary-colored filters are placed in front of a white light source. Notice that each primary-colored filter passes only its own color and absorbs the other two primary colors. It stands to reason then that when any two or all three of the primary-colored filtered overlap, no light is allowed to pass.

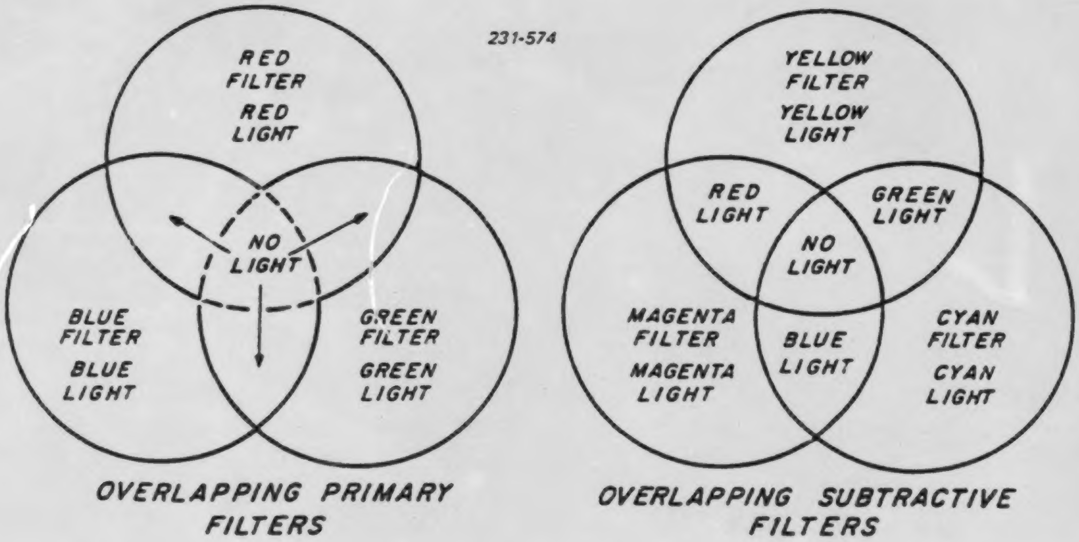

Figure 6-2. Primary and secondary filters.

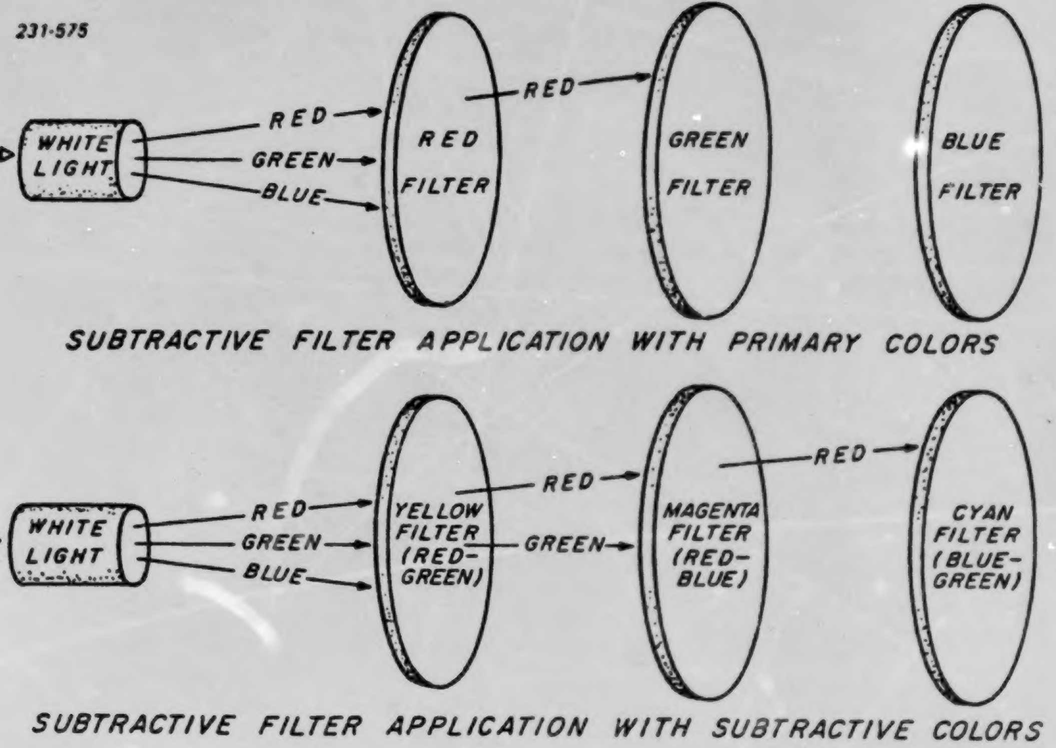
231-575
WHITE LIGHT
RED
GREEN
BLUE
RED FILTER
RED
GREEN FILTER
BLUE FILTER
SUBTRACTIVE FILTER APPLICATION WITH PRIMARY COLORS
WHITE LIGHT
RED
GREEN
BLUE
YELLOW FILTER (RED-GREEN)
RED
GREEN
MAGENTA FILTER (RED-BLUE)
RED
CYAN FILTER (BLUE-GREEN)
SUBTRACTIVE FILTER APPLICATION WITH SUBTRACTIVE COLORS

Figure 6-3. Filter application.

Now consider the effect produced by secondary-colored filters (also called *subtractive primaries.* Each secondary-colored filter passes its own color—the two colors which combine to create it. As an example, a yellow filter passes yellow light and since they combine to form yellow, also passes red and green. The yellow filter will not pass its complementary color blue, and for this reason a yellow filter is often referred to as a *minus-blue* filter. Notice that total absorption of light by secondary-colored filters occurs only when all three filters overlap.

It is helpful to think of filters in terms of the colors they subtract from white. Red is a minus blue and green while cyan is a minus red, etc. (see fig. 6-3). In this way the result of the finished print from a black and white negative which was exposed by filtered light can be rapidly calculated. Any color that is passed will print light because it creates a greater percentage of negative density when compared with the color(s) of light that are absorbed. For example, suppose you are taking a photograph of a red barn. You are using panchromatic film and a green filter. The red colored light being reflected off the barn will be absorbed while the green light reflected off the background will pass through. The result on the negative will be a thin barn and dense surrounding area. A print, therefore, will be a dark barn and light background.

NOTE: The exact transmission and absorption pattern will depend on a number of factors. The density of the filter (the darker the filter the more absorption), the exposure, the Kelvin value (i.e. color) of the lighting, and the type of film being used are all ingredients. You therefore need to experiment to insure the results you want.

Effect of Filters on the Plane of Focus. Any filter, whether located in front of or behind the lens (occasionally gelatin filters are taped to the back of the lens), will affect the plane of focus to some degree. (The thicker the filter the more the effect.) Whenever possible, it is advisable to focus the camera with the filter in place (an advantage of ground glass or reflect focusing cameras). This is especially true when high-precision close-up work is being done.

Limitations in Using Filters. You must realize that a filter must not be used indiscriminately. Film sensitivity has a great deal to do with which filters can be used. Orthochromatic film has no sensitivity to red. Using a red filter therefore would eliminate both the blue and the green, and no exposure would be obtained. The color of the illumination may also place limitations on the use of filters. If a subject is being illuminated with a pure blue light, neither red, green, nor yellow filters should be used. When filters are being used, it is essential that you be completely familiar with both the sensitivity of the film you are using and the nature of the illumination.

NOTE: Our discussion has emphasized filter application in black and white photography. The same principles apply to color photography. The main difference is that filters for color photography emphasize the secondary colors and are usually very pale in color.

Exercises (263):

1. What primary colors of light are absorbed and transmitted by the following filters or filter combinations?
   a. Blue

   b. Green and Yellow

   c. Red and Cyan

   d. Magenta

2. What filters would you not use if you had blue sensitive film in your camera? Why?

3. The thickness of the filter may cause what problem?

6-3. Filter Factor Computation

Unless you are using a very pale filter, you will need to increase your exposure when you are using a filter. To calculate the necessary increase you must understand filter factors—the subject of this section.

264. Solve exposure problems involving filter factors.

Since filters absorb light, the amount of exposure given with a filter must, in almost all cases, be greater than the exposure without a filter. How much the exposure must be increased depends upon the color and density of the filter, the color sensitivity of the film, the color of the illumination that falls upon the subject, and the reflective properties of the subject.

The exposure increase necessary for each filter is given as a filter factor number. You can obtain the specific filter factor for your film-filter combination by reading the data sheets supplied with the filter and film you are using. Then there are three methods that can be used to calculate your new exposure.

One way to use a factor is to divide the factor into the ASA or exposure index of the film you are using and then set your meter to this new figure. For example, with Kodak Tri-X Pan rated at ASA 400 and a light-green filter having a factor of 4, divide the filter factor into the film speed to calculate the new exposure index which is 100 (400 ÷ 4 = 100). Once you have set the meter at the new exposure index, you can use the meter in the normal manner. Remember, however, to reset the meter to the original ASA setting when you are not using the filter.

Another method of applying the filter factor is through the f/stop setting. Before applying this method, you must be thoroughly familiar with f/stop and their function in changing exposure. The following chart shows what the filter means when related to f/stops.

Filter Factor	2	4	6	8
Increase f/stop by	1	2	2 1/2	3

As you can see from the chart, a filter factor of 2 would require a one stop increase (doubling of exposure) from the basic setting. This would mean that if your exposure was f/8 at 1/125 and you decided to use a yellow filter with a factor of 2 your new exposure would be f/5.6 at 1/125.

A third and perhaps the easiest method to compensate for the filter factor is to multiply the exposure time by the filter factor. For example, a basic exposure without a filter is 1/500 at f/8. After installing a filter with a factor of 4, the new exposure would be calculated as follows: 1/500 × 4/1 = 1/125. The f/stop would remain the same.

Filter factors serve only as guides. The factors vary from manufacture, even with filters that appear to be the same color. Since overexposure can kill the effect of a filter, it is a good idea to bracket your exposures by full stops to make sure you get a satisfactory result.

Exercise (264):

1. Calculate the correct exposure for each of the following filter problems.
   a. Suppose you are going to use a green filter with a factor of 4. What would your new shutter speed be if your basic exposure is f/11 at 1/500?

   b. You are going to use a filter with a factor of 2. What would your new f/stop be if your basic exposure is f/22 at 1/30?

   c. Now you are planning to use a filter with a factor of 8. What would your new exposure index be if you were using a film with an ASA of 320?

6-4. Correction Filters for Black and White

In this section you will learn how correction filters can help you achieve more natural tonal reproduction in your black and white work.

265. Identify from a list the correct filter/film combination that can be used to achieve orthochromatic rendition.

There are no black-and-white panchromatic emulsions with exactly the same color sensitivity as that of the human eye. The normal eye tends to be more sensitive to green while panchromatic films are relatively more sensitive to blue or in some cases to red. The purpose of a correction filter is to absorb a portion of the color of the light to which the film is most sensitive. The film then reproduces the subject colors in shades of gray which, when printed, will correspond more closely to the way the eye would have rendered them. This type of result is called orthochromatic rendition.

The filter recommendations for correct rendering of subjects in black and white are ordinarily included in the film data sheets. The two filters recommended by "Kodak" for their panchromatic films are:

1. Daylight Lighting—No. 8 (K2)—Medium Yellow
2. Tungsten Lighting—No. 11 (X1)—Light Green

The medium yellow absorbs the excess blue that is found in daylight and to which the film is already very sensitive. This cuts down density in the sky area and, therefore, renders the sky a light gray (rather than white) in the print. The light green filter cuts down the excess red found in tungsten lighting.

NOTE: Blue sensitive and orthochromatic films cannot be used to achieve orthochromatic rendition because of their limited sensitivities.

Exercise (265):

1. Pick out which one of the following film/filter combinations can be used to achieve orthochromatic results in daylight lighting.
   a. Orthochromatic film and an orange filter.
   b. Panchromatic film and a red filter.
   c. Blue sensitive film and a red filter.
   d. Panchromatic film and a blue filter.
   e. Orthochromatic film and a yellow filter.
   f. Panchromatic film and a yellow filter.

6-5. Contrast Filters

Contrast filters are stronger than correction filters. Their purpose is to create tonal separation between two colors which otherwise would appear as the same shade of gray or to create exaggerated tonal effects. Proper use of contrast filters can make your black-and-white work more dramatic and interesting.

266. Describe the effect of using selected contrast filters in different shooting situations.

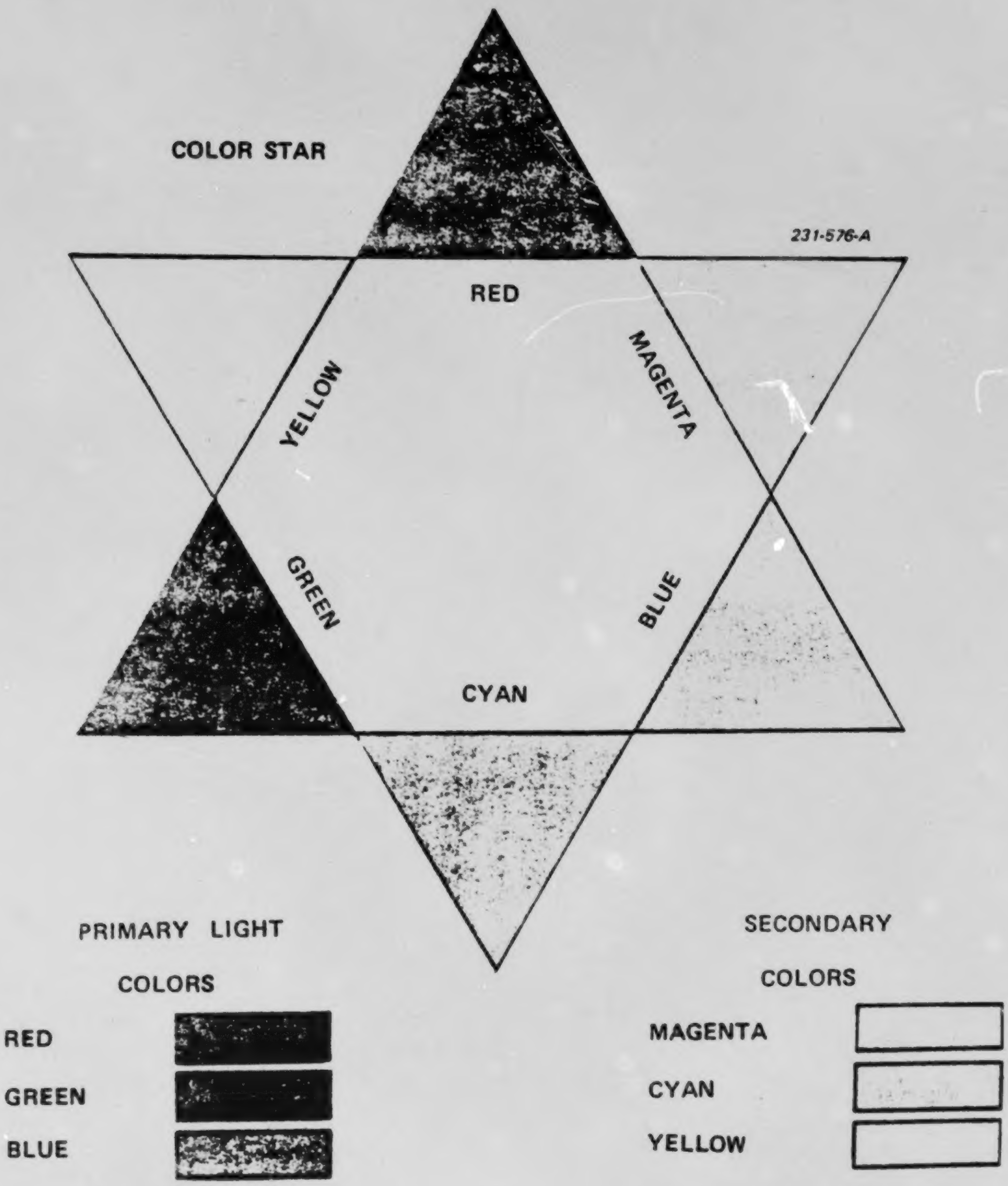

Figure 6-4A. Use of contrast filters (no filter).

Contrast filters come in a variety of colors and densities. They are identified in different ways by their manufacturers. Let us discuss the effect that a variety of contrast filters have in black and white photography.

Yellow. A yellow filter, as has been mentioned, can be used as a correction filter. It is a minus blue filter which is used to make the sky appear darker in a print. Yellow filters can be found in light, medium, and dark densities. The darker the filter the more blue that is absorbed. The medium yellow filter is probably the best all around filter for daylight black and white photography.

Orange. An orange filter absorbs more blue than a yellow one, therefore, it produces dramatic (exaggerated) contrast between sky and clouds. It can be ideal for beach and snow scenes where greater filtration of blue may be desired. It is also effective for pictures of furniture made of yellowish woods like maple, oak, or walnut.

Red. A red filter is a very strong primary filter. It absorbs a great deal of blue. It can create spectacular cloud shots as it can render the sky almost black on the print. For the same reason, it is good for architecture shots of light-tone buildings as they can be made to stand out dramatically against a darkened sky. "Fake" night shots can be made by underexposing with the red filter. A red filter (along with orange) is not usually suitable for portraiture, particularly of women, as it leads to chalky skin tones.

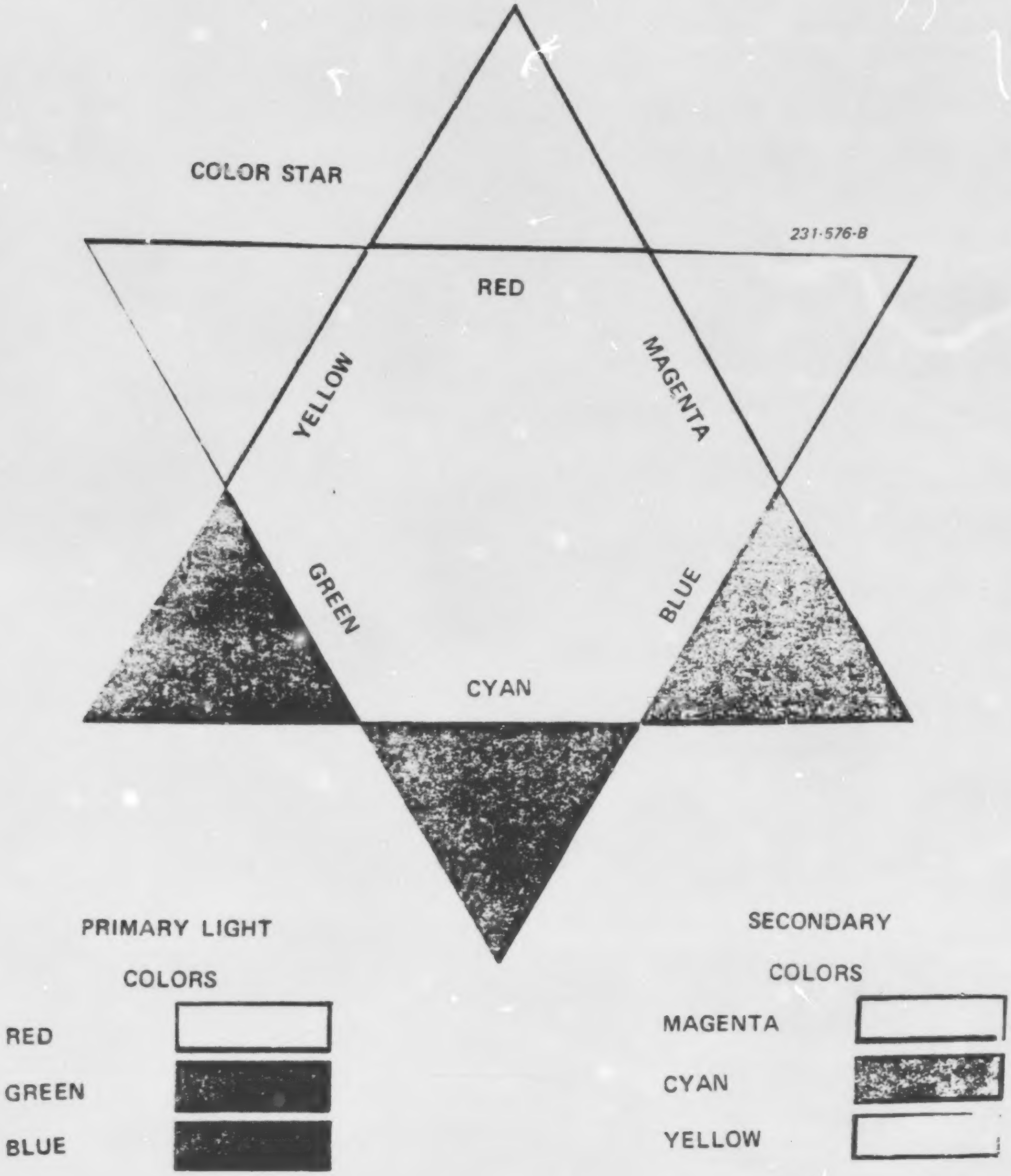

Figure 6-4B. Use of contrast filters (red filter).

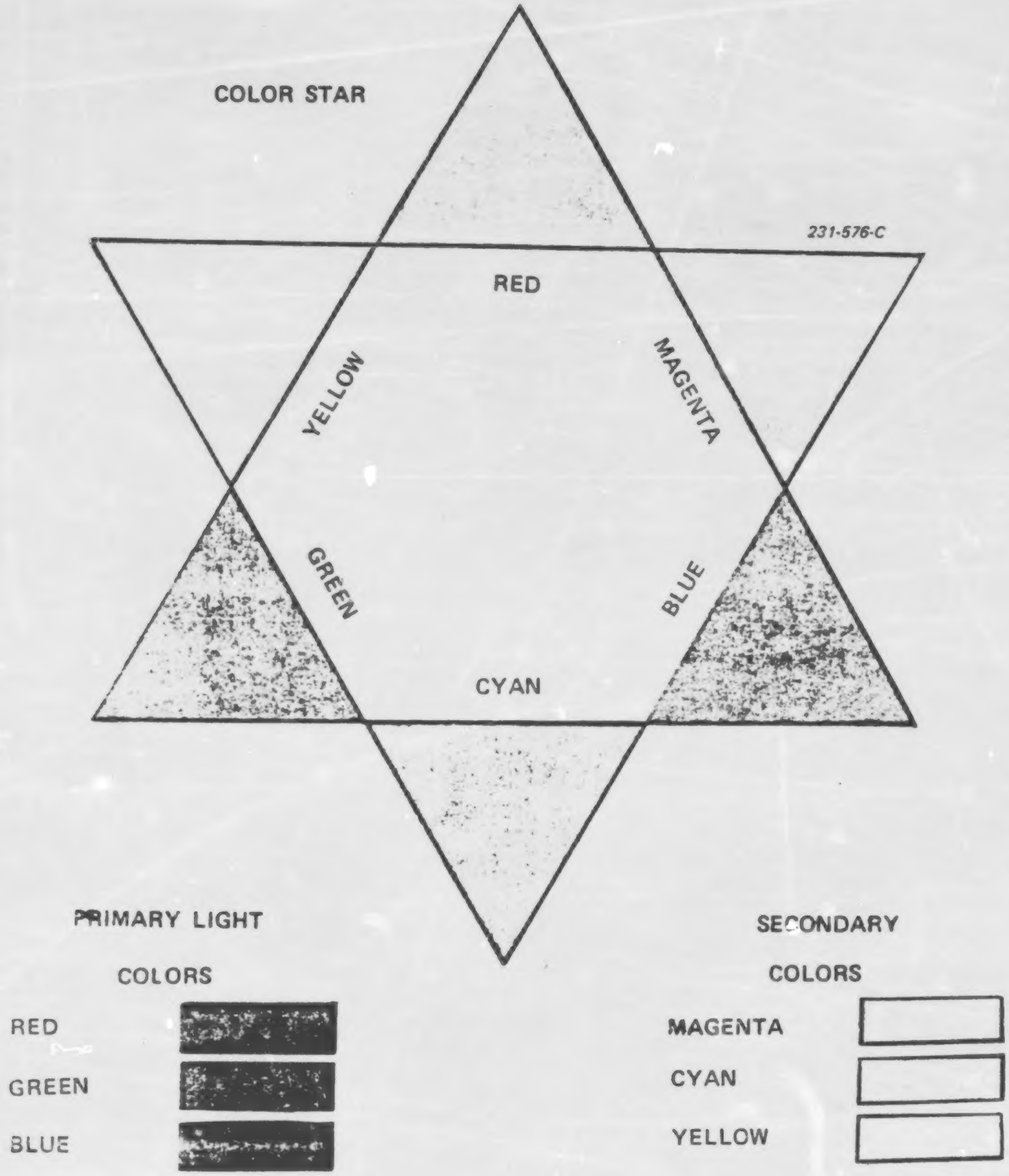

Figure 6-4C. Use of contrast filters (green filter).

Green. A green filter is excellent for outdoor scenes as it increases the contract between sky and clouds and lightens foliage, bringing out greater detail. In flower photography it is effective because it often lightens the leaves while darkening the flowers. A green filter is best for outdoor portraiture as it renders skin tones correctly. It can also be used to render the red lipstick lips of a girl darker.

Blue. A rarely used filter as it increases the density of blue relative to the other primary colors. It is used occasionally to create a "hazy" sky which can have pictorial value as it produces a greater feeling of depth.

Filters are very effective tools in black and white photography. They can create effective tonal differences which could otherwise only be accomplished by very tedious printing techniques. Look at figures 6-4A, 6-4B, 6-4C, and 6-4D to see how the color star can be rendered using different filters. Filters are easy to use. You can examine the scene through the filter to get some idea of its effect. Through practice you will know which filter will help you get the result you want.

Finally, a filter helps to protect your valuable lens.

NOTE: Proper exposure is important. Overexposure kills the effect of the filter. Underexposure creates exaggerated effects (i.e., as if you were using a denser filter). Know the filter factor of the filter you are using. The factor varies with the color and density of the filter.

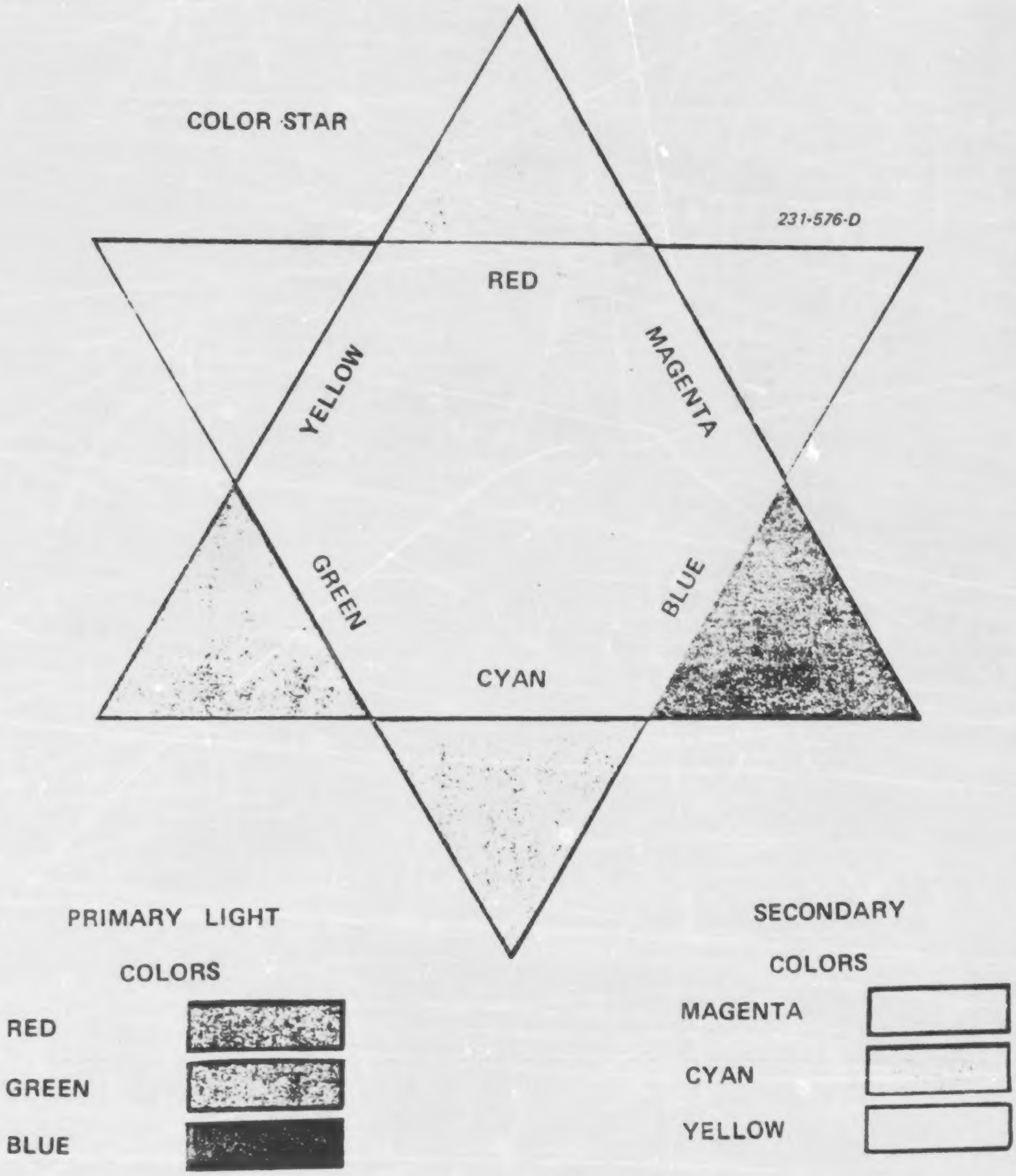

Figure 6-4D. Use of contrast filters (yellow filter).

Exercise (266):

1. Describe the final photographic print effect of using a given filter in each of the following situations.
   a. You are photographing a red rose using a red filter.

   b. You are using a green filter when photographing a meadow on a sunny day.

   c. You use an orange filter when photographing the White House on a clear day.

   d. Today you photograph a mountain scene with a blue filter.

6-6. Neutral Density Filters

Neutral density filters are another type of filter you should become familiar with. A neutral density filter can help you when you encounter high intensity lighting situations or when you want to achieve certain compositional effects.

267. Briefly explain what a neutral density filter does and how it can be used.

Neutral density (ND) filters come in different densities of gray. They are used to control the intensity, rather than the color, of light striking the film. There are two basic shooting situations where a neutral density filter comes in handy. The first is where the light intensity is so strong that overexposure will result with the film that is being used. For example, your camera may be loaded

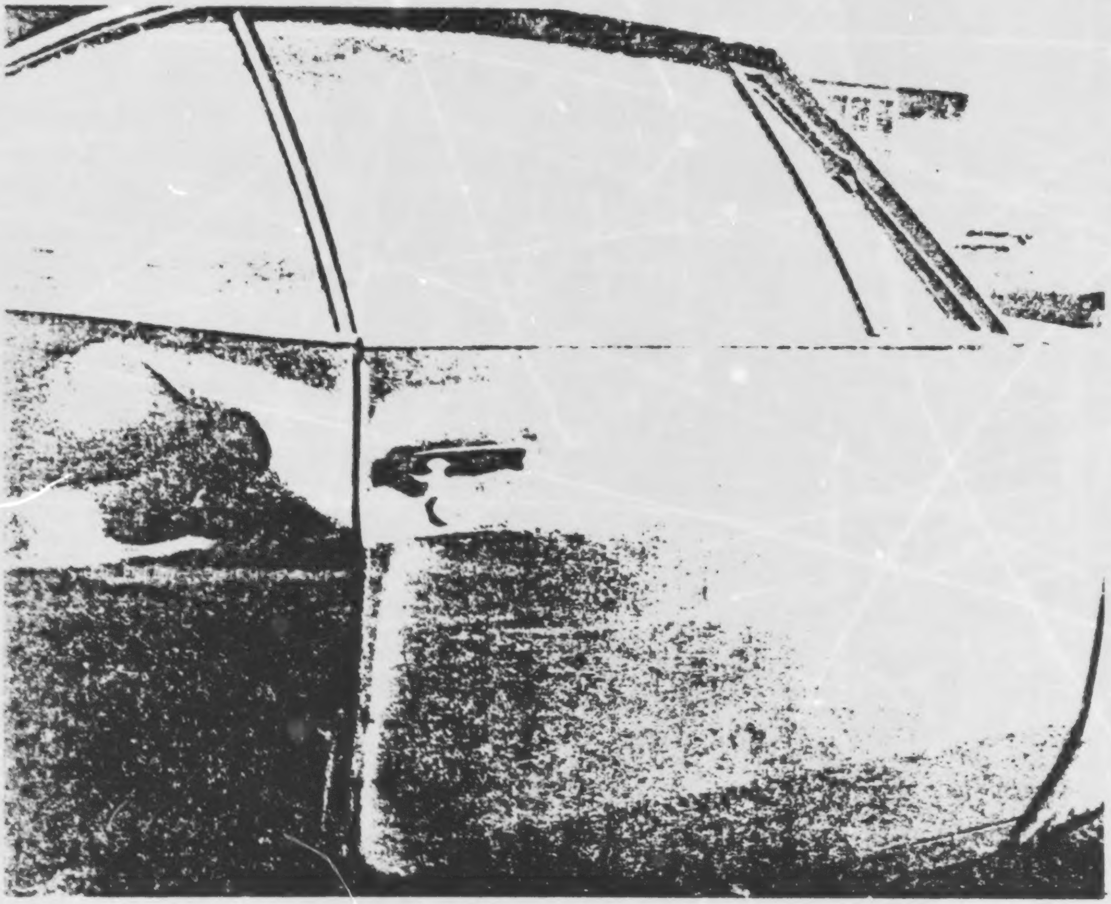

Figure 6-5A. Use of polarizing filter (no filter).

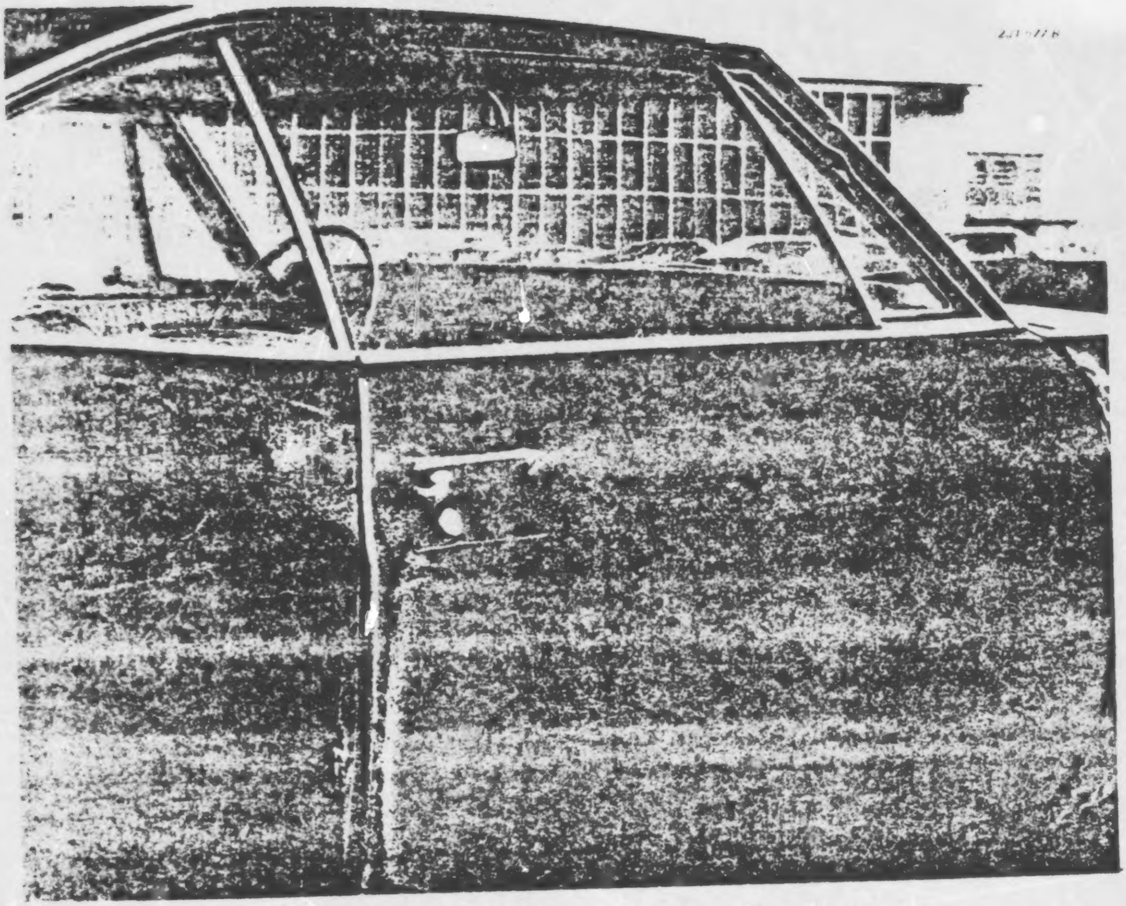

Figure 6-5B. Use of polarizing filter (polarizing filter, glass).

with film rated at 1,000 ASA and you find yourself shooting at the beach on a sunny day. Even if you use the highest shutter speed and the smallest aperture your camera has you still overexposed. The second situation is when the light is too strong for slow shutter speeds or large aperture settings which may be important for compositional reasons. For example, you may need a large aperture to achieve limited depth of field when shooting a portrait or a slow shutter speed to give the feeling of speed when shooting an auto race. If it is a bright sunny day and you have a moderate (ex. 400 ASA) speed film in your camera, your selection of shutter speed and f/stop combinations may be limited. A neutral density filter in these situations can be used to prevent overexposure.

Neutral density filters are usually identified by their density or filter factor. Here is an abbreviated list of neutral density filters that are available.

Density	*Percent of Light Transmitted*	*Filter Factor*
0.30	50%	2
0.60	25%	4
0.90	13%	7.7
1.30	5%	20
2.00	1%	100

Exercises (267):

1. Briefly explain the purpose of a neutral density filter.

2. Briefly explain two situations where a neutral density filter can be used.

6-7. Polarizing Filters

A polarizing filter is applicable to either black and white and color photography. It has very specialized applications which can help you get better pictures. Let us learn how a polarizing filter works.

268. Define polarized light and explain the purpose of a polarizing filter and how it works.

To put a polarizing filter to work it pays to understand how light travels. Light rays travel in straight lines and vibrate in all directions perpendicular to their direction of travel. If a light ray hits a nonmetallic surface, the vibrations in only one direction are reflected completely. A light ray vibrating in only one direction is considered polarized.

A polarizing filter consists of a plastic polarizing sheet between two sheets of glass in a rotatable mount. The filter allows full transmission of light waves oriented in one plane only. It therefore *polarizes* the light it *transmits.* Light attempting to pass through the filter at any other angle is attenuated or extinguished. If the light striking the filter is polarized, and the axis of the filter is oriented at 90° to the plane of that light, none of it can pass through the filter.

The filter is mounted in front of the lens, and its effect can be seen through the reflex finder or ground glass. (With a rangefinder camera you can rotate the filter in front of your eye, and once the proper result is achieved, insert the filter to match that position.) By rotating the filter, you rotate axis of polarization. If the plane of reflected light is at right angles to the axis of polarization of the lens, the reflection can be suppressed or eliminated.

The filter is excellent for reducing the glare from water, glass, oil paintings, and glossy photographs. (See figs. 6-5A and 6-5B.) The reduction of glare greatly enhances detail and color saturation. The same can happen with a blue sky which is made up of a lot of polarized light. With the sun, camera, and sky forming a right angle, the camera at the vertex, the maximum polarization of the blue sky takes place, and consequently the maximum darkening of the sky can be achieved without darkening the tone or colors in the rest of the shot. If the camera is pointed towards the sun or 180° from it, there is no such effect. A polarizing filter has a factor of about 2.5. If used with another filter you should multiply the filter factors together to get a new one to work with. When not used for polarizing, the filter acts as a neutral density filter.

Exercises (268):

1. What is polarized light?

2. What does a polarizing filter do to polarized light and to non-polarized light?

3. A polarizing filter is used on what kind of subjects?

6-8. Haze Penetrations

Haze is a problem in all outdoor daylight photography. Haze causes an overall bluish cast in color photographs, and lowers contrast in both black-and-white and color photos. This is because moisture and particles in the air scatter light as it passes through the atmosphere. The blue portion of the spectrum is affected most. Haze is a problem in scenic and aerial photography (particularly important to the Air Force). Filters and certain filter/film combinations are helpful in fighting this basic photographic problem.

269. Explain how certain filter/film combinations can penetrate haze.

Black-and-White Panchromatic Film. Due to the excess blue found in hazy conditions, a yellow, orange, or red filter coupled with panchromatic film is best suited for the job. The choice of filter depends on how bad the haze is. The darker the filter the more haze penetration, but a darker filter requires increased exposure. For example, a red filter gives good haze penetration but has a filter factor of about 8. A medium yellow or orange may prove the best for general outdoor scenics. A red might prove best for aerial work.

Black-and-White Infrared Film. Infrared film provides better haze penetration than panchromatic film because it can record the haze penetrating infrared rays which are longer than visible red. A dark red filter

150

(Wratten 29 or 70) should be used to absorb the ultraviolet and blue rays of light. Exposure should be well bracketed to insure adequate density since ordinary exposure readings will not work.

Color Film. There are three basic filters that can reduce haze in color films: Skylight, UV, and Haze. A Skylight filter (light pink in color) absorbs ultraviolet and some excess blue. A UV filter (yellowish tint) also absorbs ultraviolet and excess blue, but may add a slight overall yellowish cast to the picture. A Haze filter is practically clear and absorbs some of the ultraviolet rays without making much of a color shift.

NOTE: These three filters require no change in exposure because of their very pale nature. They also may be used with black-and-white films. A photographer often leaves one of these filters in place over the lens at all times for protection of the lens and absorption of ultraviolet light.

Color Infrared. Color infrared has good haze penetrating characteristics and is increasingly used in reconnaissance photography. The film can also be used for striking pictorial effects. When using color infrared it is recommended that you use a deep yellow filter (G15). When this is done green foliage comes out magenta, but clouds are white and the sky is blue. Other filters can be used but the colors are very distorted (i.e. with a red filter the sky is rendered green, clouds are yellow and foliage is orange).

NOTE: This is the only color film where filters designed for black-and-white photography are recommended.

Exercises (269):

1. Why is the use of panchromatic film with a red filter a good haze cutting combination?

2. What is the advantage of using infrared film to cut through haze?

3. Why is a red filter used with black-and-white infrared film?

Bibliography

Books

Bomback, Edward S. *Manual of Photographic Lighting.* London: Fountain Press Ltd., 1971.

Cox, Arthur. *Photographic Optics.* New York: Amphoto, 1971.

Souto, H. Mario Raimondo. *The Techniques of the Motion Picture Camera.* New York: Hastings House, Publishers, 1967.

Stroebel, Lesle. *View Camera Technique.* New York: Hastings House, Publishers, 1967.

Department of the Air Force Publications

AFM 52-1, *Ground Cameras and Photo Lab Equipment,* 1 November 1972.

NOTE: None of the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you may request one item at a time on a loan basis from the AU Library, Maxwell AFB, AL 36112, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of *AFMs.* TOs, classified publications, and other types of publications are *not* available.

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ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

200 - 1. a. Overcoating.
b. Emulsion.
c. Two.
d. Film base.
e. Curling; halation.

201 - 1. a. Film; processing.
b. Middle tones.
c. Slow; even.

202 - 1. Effective energy varies with the frequency of the light. The shorter wavelengths have the highest frequencies, hence the greater energy.
202 - 2. The reaction of the emulsion to light varies with the frequency of the light.
202 - 3. The normal sensitivity of a silver halide in an ordinarily prepared emulsion is limited to the ultraviolet, violet, and blue wavelengths.
202 - 4. Optical sensitization is increasing an emulsion's sensitivity to light of longer wavelengths by dyeing the silver halides.
202 - 5. Panchromatic film.

203 - 1. Film latitude is the ability of a film emulsion to record a range of subject brightness values.
203 - 2. Exposure latitude is directly related to the film's inherent latitude. If the film has excellent inherent (i.e. film) latitude, it will also have wide exposure latitude.
203 - 3. Latitude in black-and-white film is related to film speed. The faster speed black-and-white films normally have greater film or exposure latitude than slow speed films.

204 - 1. The American National Standards Institute (ANSI) establishes the procedures for determining the speed of sensitized materials so that rating systems are standardized.
204 - 2. a. Exposure.
b. 200.
c. Density.
d. Slowest.
e. Slower.

205 - 1. Contrast is the difference between the high and low densities of the various areas of the emulsion.
205 - 2. Normal contrast is represented by a full range of densities, including highlights, middle tones, and shadows.
205 - 3. Slow speed film.
205 - 4. In general, the greater the development the greater the contrast.

206 - 1. a. Many.
b. Exposure.
c. Speed; high.

207 - 1. a. Crack.
b. Reduced.
c. Fogging.
d. 60 percent.
e. Up.
f. Low.
g. Light.
h. Abrasions.
i. Breakage.

208 - 1. Orthochromatic film is sensitive to the blue and green wavelengths of visible light. Because the film is not sensitive to red, it cannot reproduce many subjects with a full range of tones.

209 - 1. c; d; f.

210 - 1. 1c; 2h; 3e; 4d; 5f; 6a.

211 - 1. a. Red.
b. Haze.
c. Increased.
d. Heavy.

CHAPTER 2

212 - 1. The exposure formula that applies to most practical work is: Exposure = Intensity x Time.
212 - 2. Intensity refers to the brightness of the light striking the film. This brightness or intensity is controlled by the aperture setting of the camera lens. Time is the interval during which the shutter permits light to reach the film.

213 - 1. Film speed indicates the sensitivity of the film to light. Films are numerically rated by the American National Standards Institute. A film speed number is directly related to any other. A film speed of 100 means the film is twice as sensitive to light as a film with a rating of 50 but is half as sensitive as a film rated at 200.

213 - 2. The combination of the shutter speed and the aperture setting determines the amount of light that is exposing the film. As the shutter speed is set to the next faster one, the exposure is reduced by one-half. Conversely as the shutter speed is changed to the next slower one, the exposure is doubled. The same principle applies to the aperture setting. Going to the next smaller aperture setting reduces exposure by one-half, and going to the next larger aperture size doubles the exposure. Therefore, various combinations of shutter speeds and apertures can transmit the same amount of light.

213 - 3. a. 1/250 at f/4.
b. 1/60 at f/11.
c. 1/250 at f/4.

214 - 1. The scene brightness range is the difference between a scene's highlights and its shadows.

214 - 2. The scene brightness range sets the contrast of the scene. If the contrast is beyond the limits of the film that is being used, shadow detail will be lost or highlights blocked up as an attempt is made to expose for this range of highlights and shadows.

215 - 1. The law of reciprocity is expressed in the formula, $E = I \times T$. This formula means that if the product of the light intensity and the time of the light action is the same for each exposure, then each sheet of film having the same film speed will have the same density when processed the same.

215 - 2. When you have conditions of extreme high or low intensities normally marked by extremely short or long exposure times, you will have reciprocity failure.

215 - 3. Reciprocity failure results in a loss of film speed which causes underexposed negatives.

216 - 1. a. True.
b. False.
c. True.

217 - 1. a. f/22.
b. f/5.6.
c. f/5.6.

218 - 1. The purpose of taking a reflected light meter reading is to measure the amount of light being reflected by the subject.

218 - 2. The purpose of taking an incident light meter reading is to measure the amount of light falling on the subject.

218 - 3. a. Subject.
b. Incident.
c. Camera.
d. Reflected.

219 - 1. An average reading is a reflected reading that is taken by pointing the meter towards the middle of the subject. The meter averages out the highlight and shadow differences. A scene brightness reading requires two reflected readings. One reading is made of the highlights and a second one of the shadows. The values of the two are then averaged to calculate the exposure.

219 - 2. An incident meter reading is valuable when you have contrasty or backlighted subjects. In both of these situations a reflected meter reading might be erroneous because of the strong highlight areas of the subject.

219 - 3. The subject chosen for the substitute should closely approximate the subject's reflectance and should be illuminated by the same light as the subject.

220 - 1. a. Blinded; sun.
b. High.
c. Bumping.
d. Zero.
e. 125° F.

221 - 1. a. True.
b. False.
c. True.
d. False.

CHAPTER 3

222 - 1. The single lens reflex uses a single lens system, while the twin lens has two matched lenses. The single lens reflex, through the use of a mirror, has no parallax problem as the photographer can see exactly what the lens sees. With the twin lens reflex, the view through the top lens may be slightly different than through the bottom taking lens, particularly at close lens-to-subject distances. Another difference is that the twin lens reflex viewing system reverses the image, unlike the single lens reflex camera.

223 - 1. a. 12.
b. Cleanliness.
c. Meter.
d. Filters.
e. Magnifier.
f. Click stops.
g. Forward; back.
h. Direct viewfinder (or sports finder).
i. Lens tissue.

224 - 1. a. Parallax.
b. 35mm; 50mm; 90mm
c. Subdued light.
d. Feet.
e. Red dot.
f. Reversing; R.
g. 1/50 second.
h. Focal plane.
i. Film counter.
j. 1/30 second.
k. 35mm.
l. Burn; hole.
m. Dry.
n. 90mm.
o. Flash bulb.

225 - 1. a. Bayonet.
b. A.
c. B.
d. Automatic diaphragms.
e. R.
f. Taking aperture.
g. 1.3.
h. Center-weighted.
i. T; shutter speed.
j. V.

k. Two seconds.
l. Shorter.
m. Green dot.
n. Titanium.

226 - 1. a. True.
b. False.
c. True.
d. False.
e. False.
f. True.
g. True.
h. False.
i. True.
j. True.

227 - 1. a. The horizontal swing back is used to correct distortion or perspective in the horizontal plane.
b. The horizontal swing front is used to focus and increase the depth of field when the horizontal swing back is set off center.
c. The vertical tilt front is used to focus and increase the depth of field when the vertical tilt back is set off center.
d. The vertical tilt back is used to correct distortion or perspective in the vertical plane.
e. The sliding front is used to center an object on the ground glass when the object is not directly in front of the lens
f. The sliding back is used for additional correction over what is provided by the sliding front.
g. The falling front is used to center the subject vertically on the ground glass when the subject is too low to the camera.
h. The rising front is used to center the subject vertically on the ground glass when the subject is too high to the camera.

228 - 1. a. 16, 22.
b. Spirit levels.
c. Revolving back.
d. Ground glass.
e. Tripod.
f. Rear standard.
g. Front.
h. Leaf.
i. 12; 30.

229 - 1. a. False.
b. False.
c. True.
d. True.
e. False.
f. True.
g. True.
h. True.

230 - 1. a. 35mm.
b. Electronic flash.
c. Camera; lens carriage.
d. 1/2.
e. 4X.
f. Emulsion down.
g. Shutter.
h. Emulsion up.

231 - 1. a. 16mm.
b. 100.
c. 24; 400.
d. 3.
e. 4; 6.
f. Critical focuser; focusing scale.
g. 16.
h. Rotary-disc.
i. 1/40.

232 - 1. a. Direct.
b. Six.
c. 16.
d. 24.
e. Slow motion.
f. Speed.
g. Diaphragm.
h. Tripod; exaggerated.
i. 24.
j. Hand crank.
k. Opening; closing; diaphragm.
l. Lap dissolve.
m. Focusing; composition.
n. Backwind.
o. Backwinding.

CHAPTER 4

233 - 1. Focal length is defined as the distance from the optical center of the lens to the image produced by the lens at the focal plane, when the lens is focused on infinity.

234 - 1. F/stops are calculated by dividing the focal length of the lens by the diameter of the aperture.

234 - 2. With each f/stop change to a smaller aperture (larger f/stop number) half as much light is admitted as compared to the previous f/stop. With each f/stop change to a larger aperture (smaller f/stop number) twice as much light is admitted as compared to the previous f/stop.

235 - 1. The speed of the lens is calculated by dividing the focal length of the lens by the diameter of the maximum aperture.

236 - 1. Circle of illumination is the circular field of light that is projected by a positive lens.

236 - 2. The usable circle of illumination is determined by including only that portion of the total circle of illumination that has sufficient intensity to produce satisfactory images.

237 - 1. The angle of field of a lens is the widest angle at which light enters the lens and produces the usable portion of the circle of illumination. The angle of view is the angle of light that is necessary to provide adequate coverage of the film that is being used. It may be equal to but is never greater than the angle of field.

238 - 1. Resolution refers to the ability of a photographic lens or material to record fine detail. The normal method of measuring this quality is to photograph a suitable test pattern at a greatly reduced scale, and then examine the developed image under adequate magnification to calculate the smallest detail.

238 - 2. Definition refers to the quality aspect of a photograph that is associated with the clarity of detail. It is a subjective evaluation based on an observer's view of the photograph.

239 - 1. The purpose of coating a lens is to improve light transmission and reduce optical flare.

239 - 2. The lens should be cleaned with the proper tools. These include: a fine brush, lens tissue, and lens cleaning solution. Throughout the process of dusting, cleaning, and polishing there should be no undue pressure that would "rub-off" the lens coating.

240 - 1. A normal lens has a focal length that is about equal to the diagonal dimension of the film being used.

241 - 1. a. Shorter. b. Smaller. c. Depth of field. d. Center; edges.

242 - 1. A long-focal-length lens has a focal length greater than the diagonal dimension of the film.

242 - 2. The narrower angle of coverage and the larger image size for a given subject-to-camera distance produced by a long focal-length lens isolates the subject from its surroundings. A short focal length lens has much wider coverage and, thus, a problem of creating a strong point of interest.

242 - 3. Long-focal-length lenses magnify camera shake, and it is necessary to use high shutter speeds to correct this problem.

243 - 1. a. True.
b. True.
c. False.
d. True.
e. False.

244 - 1. The two controls that determine image size are: (1) the focal length of the lens that is used and (2) the lens-to-subject distance. The longer the focal length, the larger the image size. The closer the lens-to-subject distance, the larger the image size.

245 - 1. Perspective is controlled entirely by the camera-to-subject relationship. The shooting position sets the relationships of all objects in the scene.

245 - 2. Focal length controls image size but not the relationship of one object to another. Changing to a different focal length proportionally changes all of the subject sizes but not their relationships.

245 - 3. 16 x 20.

246 - 1. Image-forming light passing through a photographic lens forms small circles of light on the film plane. How sharp, small, and well defined these "circles of confusion" are determine how sharp the image will be. When the image is focused so that the circles of confusion are the smallest possible for that lens, the image is said to be in critical focus.

247 - 1. Depth of field is the distance from the nearest plane in acceptable focus to the farthest plane in acceptable focus.

247 - 2. 1. Focal length. The shorter the focal length of the lens the greater the depth of field.
2. Lens-to-subject distance. The greater the lens-to-subject distance, the greater the depth of field.
3. The aperture. The smaller the f/stop setting, the greater the depth of field.

248 - 1. Depth of focus is the distance in front of and behind the film that renders acceptably sharp images.

248 - 2. 1. Focal length. The longer the focal length of the lens, the greater the depth of focus.
2. Lens-tosubject distance. The shorter the lens-to-subject distance, the greater the depth of focus.
3. The aperture. The smaller the f/stop setting, the greater the depth of focus.

249 - 1. 4 feet.

250 - 1. The critical aperture is that lens aperture that transmits the sharpest image.

251 - 1. Mechanical flare is caused by reflections that occur off the lens barrel or camera. These reflections are usually caused because a metal surface has been damaged or burnished. The method of correction is to coat these surfaces with a nonreflective coating.

251 - 2. Optical flare is caused by reflections off the glass surfaces of the lens. Such flare can be reduced or eliminated by a proper lens coating and the use of a lens shade.

CHAPTER 5

252 - 1. Light is a form of wave (radiant) energy.

252 - 2. Radiant energy is measured by frequency or wavelength.

252 - 3. The product of frequency and wavelength determine the speed of travel of a given form of radiant energy.

252 - 4. Due to the difficulty in measuring frequency, wavelength in air is used to identify different types of radiant energy.

252 - 5. Wavelengths of energy that can be controlled by the laws of optics (ex. bent by a lens) form the optical spectrum.

252 - 6. Violet.

252 - 7. Red.

253 - 1. a. Transmission is the principle of light passing through a non-opaque medium.
b. A translucent medium is one that diffuses the light that is transmitting through it. Frosted glass is an example of a translucent medium.
c. A specular reflection is one that returns in the same plane and at the same angle as the incident light.
d. The color of an object is determined by the manner in which it reflects and absorbs light.
e. Brightness of a particular color will affect how much light will be reflected by it. A bright color will reflect more light than a dull color of the same tint.

f. A normal ray is one that does not change its direction as it passes through a particular medium.

g. Dispersion is the breaking up of white light into its different colors.

h. The Law of Refraction states: If light enters a medium of different density at an oblique angle, its direction is changed so that the ray of light is bent toward the normal if the medium is more dense, or away from the normal if the medium is less dense.

254 - 1. a. False.
b. True.
c. True.
d. True.
e. False.
f. False.

255 - 1. Electronic flash units are light, convenient, and powerful.

255 - 2. Electronic flash gives a penetrating light which gives good shadow detail. Its brief flash eliminates the problems of eye contraction. Not being a continuous light source the subject is not bothered by hot glaring lights. All these make electronic flash ideal for portrait photography.

255 - 3. Guide numbers for electronic flash are based on the output of the unit in relation to the film speed being used.

255 - 4. A ghost image may be caused when you use a shutter speed that is slow enough for an image to be formed by the available light as well as by the flash.

256 - 1. Flash synchronization is a system whereby the camera shutter mechanism is designed to complete the electrical circuit of the flash at the proper time.

256 - 2. An electronic flash reaches its peak of intensity almost instantaneously. Therefore electronic flash is "X" synchronized to go off as soon as the shutter is tripped. This principle makes synchronization with a leaf shutter easy, because a leaf shutter opens up and exposes the entire film format once the shutter is released regardless of the shutter speed that is chosen. As long as the shutter speed is not shorter than the peak duration of the flash being used, the entire film format will be properly exposed. However, a focal plane shutter uses a curtain type arrangement. At high shutter speeds, the film is exposed by moving a slit across the width of the film format. Though each part of the film is exposed only for a brief time, it takes quite a big longer for the slit to move across the entire film format. The result is that there will not be even exposure. Therefore, synchronization is possible only at slower shutter speeds where the focal plane shutter works by using a large slit that exposes the entire film format at one time. For most focal plane cameras this means a shutter speed of about 1/60 when using electronic flash.

257 - 1. Bounce lighting is preferred because it provides a diffused light that eliminates the harsh shadows that result from direct flash.

257 - 2. Open flash is non-synchronized flash. The shutter is opened, the flash is tripped, and then the shutter is closed.

257 - 3. A slave unit is an electronic flash unit that is tripped by a photocell which reacts to the flash which is synchronized to the camera. Slave units are used in multilight arrangements.

258 - 1. a. Continuous.
b. Insufficient output.
c. Red.
d. Fine alloy wire.

259 - 1. Flashbulbs take about 20 milliseconds to reach their peak. The shutter, therefore, must be stopped from fully opening until this peak is reached. "M" synchronization holds the shutter for about 15 milliseconds to accomplish this task.

259 - 2. Lighting ratio is the difference in intensity between the highlights and the shadows. The lighting ratio can be changed through positioning of the lights and the control of their intensity.

259 - 3. Synchro-sunlight photography is using flash outdoors to reduce the intensity of shadows caused by bright daylight lighting.

259 - 4. The necessary steps are:
(1) Using a meter compute the correct exposure for the highlight area of the subject.
(2) Find the guide number for the unit, film, and shutter speed being used.
(3) Divide the guide number by the f/stop chosen for the exposure. The resulting number is the flash-to-subject distance that should be used.

259 - 5. The second lamp acts as a fill-in light to reduce shadows.

260 - 1. a. f/11 (125 ÷ 10).
b. 11 feet (125 ÷ 11).
c. f/5.6 (140 ÷ 13 plus opening two f/stops).

261 - 1. c; d; e; f; h.

CHAPTER 6

262 - 1. The two advantages in using gelatin filters are that they are inexpensive and come in a wide variety of colors.

262 - 2. Glass filters are quite durable as compared with gelatin filters.

262 - 3. All filters fade in time and have to be replaced.

263 - 1. a. A blue filter transmits blue and absorbs green and red light.
b. A combination of a green and yellow filter would transmit green and absorb red and blue.
c. The complementary combination of red and cyan would absorb all colors of light.
d. Magenta would pass red and blue and absorb green light.

263 - 2. Red, green, and yellow filters should not be used with blue sensitive film, since it is sensitive only to blue and ultraviolet light. Any filter that would completely absorb blue would be unsuitable.

263 - 3. The thickness of the filter can cause focusing problems. The thicker the filter, the greater the alteration to the light waves. It is therefore best to focus with the filter in place.

264 - 1. a. 1/125.
b. f/16.
c. ASA 40.

265 - 1. f.

266 - 1. a. The rose appears light and the green leaves appear quite dark.
b. Using a green filter gives the sky a more natural tone and produces more detail in the grassy meadow.
c. The orange filter causes the sky to appear quite dark and the White House to stand out to a greater degree.
d. The blue filter causes the sky to appear quite light and hazy with little detail. This can give quite a feeling of depth.

267 - 1. The purpose of a neutral density filter is to cut down the intensity of the light striking the film without changing its color quality.
267 - 2. (1) By using a neutral density filter you can prevent overexposure when you are using a highspeed film in a high intensity lighting situation. (2) By using a neutral density filter you may be able to select large aperture settings or slow shutter speeds for compositional reasons and yet not be overexposed.

268 - 1. Polarized light is light that is vibrating in only one direction.
268 - 2. A polarizing filter blocks polarized light that is perpendicular to it. The filter polarizes non-polarized light.
268 - 3. A polarizing filter is used to cut down reflections from non-metallic surfaces and to darken blue skies.

269 - 1. In a hazy situation you have an excess of blue. A red filter absorbs blue to a greater degree than other filters, and therefore permits a greater percentage of haze cutting red wavelengths of light from the image on the film.
269 - 2. Infrared film is sensitive to infrared waves which are longer than red. The longer wavelengths of light are better able to cut through haze. This results in greater detail.
269 - 3. A red filter is used with infrared film to absorb blue and ultraviolet wavelengths. This insures that the image will be formed by red and infrared wavelengths.

STOP— **1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.** **2. USE NUMBER 1 OR NUMBER 2 PENCIL.**

23132 02 21

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

STILL PHOTOGRAPHIC FUNDAMENTALS

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that numerical sequence on answer sheet alternates across from column to column.
3. Use a medium sharp #1 or #2 black lead pencil for marking answer sheet.
4. Circle the correct answer in this test booklet. After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'TS:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #1 or #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers.* The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (200) Which of the following gives film its basic characteristics?

    a. The emulsion coating.
    b. The substratum coating.
    c. The base.
    d. The antihalation coating.

2. (200) The majority of film bases are made out of

    a. glass.
    b. cellulose nitrate.
    c. silver nitrate.
    d. cellulose acetate.

3. (201) Generally, the faster the film speed the

    a. more limited the latitude.
    b. greater the graininess.
    c. higher the contrast.
    d. more limited the spectral sensitivity.

4. (201) Grain is most apparent in what area of a print?

    a. In the highlights.
    b. In the middle tones.
    c. In the shadows.
    d. In the borders.

5. (202) A film that is sensitive only to the blue and green wavelengths of light would be described as being

    a. panchromatic.
    b. orthochromatic.
    c. blue sensitive.
    d. infrared.

6. (203) Normally, exposure latitude is

    a. inversely proportional to film speed.
    b. inversely proportional to contrast latitude.
    c. directly proportional to film latitude.
    d. inversely proportional to film latitude.

7. (204) Based on ASA ratings, which of the following films would be most sensitive to light?

    a. 60.
    b. 125.
    c. 250.
    d. 400.

8. (205) The difference in brightness between a subject's highlights and shadows is called

    a. the subject curve.
    b. the range zone.
    c. contrast.
    d. the subject zone.

9. (205) A high inherent film contrast is usually associated with a

    a. grainy film.
    b. slow-speed emulsion.
    c. reduced development.
    d. high-speed emulsion.

10. (206) Photographic resolution improves with

    a. overexposure.
    b. graininess.
    c. underexposure.
    d. a slow-speed emulsion.

11. (207) An extremely low storage temperature will have all of the following effects upon film *except* for

a. an increased brittleness.
b. a reduced film speed.
c. shrinkage.
d. an increased contrast.

12. (207) Film should be stored at low temperatures where the relative humidity does *not* exceed

a. 50 percent.
b. 60 percent.
c. 70 percent.
d. 80 percent.

13. (207) Glass plates are used primarily in what area of photography?

a. Motion pictures.
b. Photojournalism.
c. Scientific.
d. Sports.

14. (208) Orthochromatic film would be suitable to photograph which of the following subjects?

a. A stop sign.
b. A woman's portrait.
c. A red apple.
d. A man's portrait.

15. (209) Type C panchromatic film is more sensitive to which color of light than other types of panchromatic film?

a. Red.
b. Blue.
c. Green.
d. Infrared.

16. (210) What type of Polaroid film with an ASA rating of 400 will produce a 4" x 5" image?

a. 42.
b. 47.
c. 52.
d. 105.

17. (211) To achieve proper focusing when using infrared film, the lens-to-film distance should be

a. doubled.
b. slightly increased.
c. slightly decreased.
d. halved.

18. (211) How will the density of natural foliage appear on an infrared negative as compared to that of a panchromatic negative?

a. It will be lighter.
b. It will be the same.
c. It will be darker.
d. It will be darker only if a green filter is used.

19. (212) What is the basic exposure formula?

a. E = I X T.
b. E = F X S^2.
c. E = A X T.
d. E = D X X.

20. (213) What does the term "close down one stop" mean?

a. Increase your exposure by one-half.
b. Increase your exposure by one-quarter.
c. Reduce your exposure by one-half.
d. Reduce your exposure by one-quarter.

21. (214) The scene brightness range is the relative difference between

a. the different shades of colors.
b. highlights and shadows.
c. the different middle tone light intensities.
d. the different shades of gray.

22. (215) The reciprocity law is expressed by the equation

a. $E = I \times T$.
b. $E = S^2 \times F$.
c. $R = S \times F$.
d. $R = \frac{I \times T}{2}$.

23. (215) A reciprocity failure will result in

a. an increased resolution.
b. a loss of film speed.
c. a lens aberration.
d. a reduced development time.

24. (216) Which of the following filter/film combinations will best penetrate a heavy haze?

a. Orthochromatic film and an orange filter.
b. Panchromatic film and a red filter.
c. Panchromatic film and a blue filter.
d. Infrared film and a dark red filter.

25. (217) When using a data guide chart, a snow scene should be placed under which subject brightness category?

a. Brilliant.
b. Bright.
c. Average.
d. Dark.

26. (218) What type of exposure meter will measure the light falling on the subject?

a. Reflective.
b. Spot.
c. Incident.
d. Three-point.

27. (219) When you aim a reflected exposure meter toward the middle of the subject, you are taking what kind of a meter reading?

a. Average.
b. Brightness range.
c. Substitute reading.
d. Incident.

28. (220) When operating an exposure meter, you should do all of the following except to

a. zero the meter.
b. protect the meter from being bumped about.
c. protect the meter from high temperatures.
d. take a meter reading of the sun.

29. (221) The gray side of a gray card will reflect what percentage of incident light falling upon it?

a. 18 percent.
b. 35 percent.
c. 90 percent.
d. 5 percent.

30. (222) The top lens of a twin lens reflex is used for

a. taking the picture.
b. viewing.
c. placement of the diaphragm.
d. backing up the bottom lens in case of a malfunction.

31. (223) The "Rolleiflex" camera features all of the following except

a. a twin lens.
b. the use of 120 film.
c. a built-in flash synchronization.
d. fully interchangeable lenses.

32. (223) Which of the following describes the "Rolleiflex" camera.

a. A 35mm single lens reflex camera with interchangeable lenses.
b. A view camera with wide application in industrial photography.
c. A twin lens reflex camera designed for 220 film.
d. A 35mm rangefinder camera that is ideal for combat work.

33. (223) The direct viewfinder on the "Rolleiflex" is ideal to use on which type of assignment?

a. Closeups.
b. Sports.
c. Studio portraits.
d. Architectural.

34. (224) The rangefinder focusing system has all of these features except

a. parallax problems.
b. a comparable bright image in low light.
c. rangefinder synchronization problems.
d. no limitations on the focal length of the lenses used.

35. (224) The "Leica" M-2's viewfinder has frame lines covering which of the following focal lengths?

a. 35mm, 50mm, 90mm.
b. 50mm, 85mm, 105mm.
c. 50mm, 90mm, 135mm.
d. 90mm, 135mm, 180mm.

36. (224) Normally, when loading film into the "Leica" M-2, you should be

a. in total darkness.
b. under a red safelight.
c. in a subdued light.
d. in bright sunlight.

37. (224) The preview selector on the "Leica" M-2 helps the photographer to

a. choose the appropriate lens.
b. evaluate depth of field.
c. check focus.
d. check exposure levels.

38. (225) When using the T shutter setting, the "Nikon" F shutter is closed by

a. releasing a cable release.
b. resetting the self-timer.
c. rotating the shutter speed dial.
d. resetting the film speed dial.

39. (225) A single advance of the "Nikon" F film advance lever does all of the following except to

a. advance the film.
b. cock the shutter.
c. advance the exposure counter.
d. activate the meter.

40. (226) The three methods of focusing the "Super Speed Graphic" involve the

a. sports finder, focusing scale, and ground glass.
b. viewfinder, sports finder, and ground glass.
c. rangefinder, sports finder, and focusing scale.
d. rangefinder, ground glass, and focusing scale.

41. (226) How many different methods can be used to release the shutter on the Super Speed Graphic camera?

a. 1.	c. 3.
b. 2.	d. 4.

42. (227) When using a view camera, what combination of controls are used to position the image on the ground glass (film plane)?

a. Front swings and tilts.
b. Rising, falling, and sliding movements.
c. Back swings and tilts.
d. Rotating back and vertical swings.

43. (227) Which view camera movement is used to correct distortion or perspective in the horizontal plane?

a. Horizontal swing front.	c. Horizontal swing back.
b. Vertical tilt front.	d. Sliding back.

44. (227) A maximum depth of field in the vertical, horizontal, or intermediate plane with a view camera is achieved through the use of the

a. rising and falling front.	c. sliding back.
b. front tilt and swing.	d. back tilt and swing.

45. (228) The "Calumet" view camera has all of the following features except

a. 30° vertical tilts.	c. spirit levels.
b. a revolving back.	d. 15° horizontal swings.

46. (229) The "Princeton" Model 17 copy camera is used in the horizontal position to copy

a. printed circuits.	c. exploded views.
b. solid objects.	d. transparencies.

47. (230) The "Repronar" 805 camera is designed to copy what maximum size transparencies to 35mm film?

a. 4" x 5".	c. 2 1/4" x 2 1/4".
b. 2 1/4" x 3 1/4".	d. 100mm.

48. (230) The type of light source used by the "Repronar" 805 camera is a

a. built-in electronic flash.	c. photoflood.
b. tungsten bulb.	d. quartz iodine lamp.

49. (230) To set the correct exposure and filtration on the "Repronar" 805 camera, you must know the

a. size of film you are copying.	c. aperture you are using.
b. film value you are using.	d. degree of magnification.

50. (231) What is the maximum length film magazine which can be used on the B-1A "Bell and Howell" 70-KM camera?

a. 100 feet.	c. 300 feet.
b. 200 feet.	d. 400 feet.

51. (231) The 17mm lens for the B-1A camera can be turret mounted with which combination of lenses?

a. 1" and 2".
b. 2", 3", and 4".
c. 3" and 6".
d. 4" and 6".

52. (232) How much initial footage is used as a light-proof protective leader on the B-1A camera when a paper leader is not provided?

a. 4 feet.
b. 6 feet.
c. 8 feet.
d. 10 feet.

53. (232) A speed of 64 frames per second with the B-1A camera will give what effect?

a. Slow motion.
b. Overexposure.
c. Underexposure.
d. Accelerated motion.

54. (232) Backwinding on the B-1A camera is used to achieve all of the following effects except

a. slow motion.
b. double exposures.
c. titles on a moving background.
d. lap-dissolves.

55. (233) The distance from the optical center of the lens to the image produced by the lens at the focal plane when the lens is focused on infinity is the

a. optical length.
b. conjugate distance.
c. focal length.
d. hyperfocal distance.

56. (234) The formula used to calculate f/stops is

a. $f = \frac{FL}{D}$.
b. $f = FL \times D$.
c. $f = \frac{D}{FL}$.
d. $f = FL - D$.

57. (235) The speed of a lens is calculated by dividing the focal length of the lens by the diameter of the

a. critical aperture.
b. maximum aperture.
c. hyperfocal aperture.
d. minimum aperture.

58. (236) All of the following statements regarding the circle of illumination are true, except that the circle of illumination

a. is formed by a positive lens.
b. includes the usable circle of illumination.
c. can be formed by a negative lens.
d. forms a sharp image in the center but not at the edges.

59. (237) The maximum coverage of a lens is expressed in degrees as being the

a. focal length.
b. angle of field.
c. angle of view.
d. optical coverage.

60. (238) The ability of a lens to record fine detail is called its

a. optical sensitivity.
b. definition.
c. acutance.
d. resolving power.

61. (239) A photographic lens should be cleaned with

a. Kleenex.
b. an eyeglass tissue.
c. a lens tissue.
d. a chemical wipe.

62. (240) The normal focal length of a lens for a 35mm film should be

a. 35mm.
b. 50mm.
c. 90mm.
d. 150mm.

63. (241) All of the following are advantages associated with a wide angle lens except for

a. an ease of composition.
b. a short focal length.
c. a good depth of field.
d. an ability to "zone focus."

64. (242) By adapting a normal lens from an 8 x 10 camera to a 4 x 5 camera, you would have a

a. wide angle lens.
b. normal lens.
c. long-focal-length lens.
d. telephoto lens.

65. (242) Each of the following are true statements about a long-focal-length lens except that it

a. is like a telescope.
b. has a narrow angle of coverage.
c. has a focal length greater than the diagonal dimension of the film.
d. has a great depth of field.

66. (243) Which of the following statements is true of a telephoto lens?

a. It has the same design as a long-focal-length lens.
b. It is adapted for fast shutter speeds.
c. It uses a special design to achieve a long-focal-length effect.
d. It uses a positive rear element to achieve a long effective focal length.

67. (244) Image size can be controlled by the

a. lens focal length.
b. depth of field.
c. aperture selection.
d. shutter speed selection.

68. (245) What is the normal reading distance?

a. 6 inches.
b. 9 inches.
c. 12 inches.
d. 15 inches.

69. (246) The circles of confusion for a moderate enlargement should not have diameters that exceed what fraction of the focal length of the lens?

a. 1/1000.
b. 1/2000.
c. 1/3000.
d. 1/4000.

70. (247) All of the following factors affect the depth of field except the

a. focal length of the lens.
b. lens-to-subject distance.
c. shutter speed selection.
d. aperture setting.

71. (248) The depth of focus increases with

a. a decrease in focal length.
b. an increase in subject-to-lens distance.
c. an increase in shutter speed.
d. the selection of a smaller aperture.

72. (249) Assume that you are photographing a subject that is 10 feet from the lens. It is calculated that the distance from the subject to 9 feet beyond will be acceptably sharp. What should the zone of acceptable sharpness be, starting with the subject and going toward the camera?

a. 7 feet.
b. 6 feet.
c. 5 feet.
d. 4 feet.

73. (250) The critical aperture is

a. the same for all lenses.
b. used to achieve maximum depth of field.
c. only of concern to the lens manufacturer.
d. used to achieve a maximum sharpness.

74. (251) Mechanical flare is

a. corrected by using a nonreflected coating.
b. caused by reflections from the glass-to-air surfaces.
c. found in every lens.
d. corrected by using a lens shade.

75. (252) Which of the following types of radiant energy does not conform to the optical spectrum?

a. Ultraviolet.
b. Infrared.
c. Visible light.
d. X-rays.

76. (253) When light strikes a surface, each of the following can occur except for

a. transmission.
b. reflection.
c. conversion.
d. absorption.

77. (253) The reflection off a highly polished surface is likely to be

a. specular.
b. diffused.
c. dispersed.
d. diffracted.

78. (253) The breaking up of white light into its constituent colors is caused by

a. diffusion.
b. refraction.
c. reflection.
d. dispersion.

79. (254) The biggest variation in the nature of daylight at any given moment is caused by the

a. season of the year.
b. time of day.
c. weather.
d. geography.

80. (255) Which of the following is not a characteristic of an electronic flash?

a. It is suitable for portraiture.
b. It has a penetrating light source.
c. It has a short flash duration.
d. It has a high-heat production.

81. (256) What type of synchronization is used with an electronic flash?

a. "E."
b. "FP."
c. "M."
d. "X."

82. (257) Which method of using an electronic flash is most likely to approximate the effects of natural lighting?

a. An on-camera flash.
b. A multiple electronic flash.
c. Bounce lighting.
d. Spot lighting.

83. (258) Incandescent lighting basically depends upon what factor for light?

a. Special circuitry.
b. Heat.
c. Gases.
d. Cosmic rays.

84. (258) Which of the following is not a characteristic of flashbulbs?

a. They provide a continuous light source.
b. They give off heat.
c. They come in different sizes.
d. They depend on the combustion of a hair-fine alloy wire.

85. (259) What type of synchronization is used with the majority of flashbulbs?

a. "F."
b. "FP."
c. "M."
d. "X."

86. (259) Assuming the correct exposure for the highlight area of a subject is f/11 at 1/250 and assuming the guide number is 110, what should the flashbulb-to-subject distance be?

a. 5 feet.
b. 10 feet.
c. 13 feet.
d. 20 feet.

87. (260) Assuming your flash guide number is 110 and your flash-to-subject distance is 10 feet, what should your f/stop setting be?

a. f/8.
b. f/11.
c. f/16.
d. f/22.

88. (260) What percentage of the light of a flash fired in a room will go directly to the subject?

a. 75 percent.
b. 50 percent.
c. 25 percent.
d. 18 percent.

89. (261) Which of the following light sources would maintain the most constant color quality and brilliant form of illumination?

a. Household lamps.
b. Photofloods.
c. An electronic flash.
d. Quartz iodine lamps.

90. (261) Which of the following characteristics does not apply to the quartz-iodine lamp?

a. It is cool burning.
b. It should be handled with gloves.
c. It creates a regeneration cycle.
d. It has a high-heat intensity.

91. (262) Which of the following materials should be used as a filter for odd-sized lenses?

a. Gelatin.
b. Plastic.
c. Tissue.
d. Optical glass.

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92. (263) Which of the following combinations contains all the photographic primary colors?

a. Red, blue, green.
b. Red, yellow, green.
c. Blue, orange, green.
d. Yellow, magenta, cyan.

93. (263) What effect does a blue filter have on the color blue in relation to other colors when the photograph is printed in black and white?

a. It will have no effect.
b. It will be lighter.
c. It will be darker.
d. It will appear to be black.

94. (264) When using a filter with a factor of 8 and a basic exposure of f/22 at 1/125, the correct f stop should be?

a. 16.
b. 11.
c. 8.
d. 5.6.

95. (264) If your basic exposure is f/8 at 1/240, what should the shutter speed setting be when using a filter with a factor of 4?

a. 1/30.
b. 1/60.
c. 1/125.
d. 1/250.

96. (265) What correction filter should be used to achieve an orthochromatic rendition outdoors when using panchromatic film?

a. Medium yellow.
b. Light blue.
c. Orange.
d. Red.

97. (266) What contrast filter should be used in photographing a red flower against green leaves when the flower is to appear dark in the print?

a. Red.
b. Blue.
c. Green.
d. Yellow.

98. (267) What type of filter should be used to provide a correct exposure if the intensity of light is so great that overexposure will result?

a. Contrast.
b. Polarizing.
c. Correction.
d. Neutral density.

99. (268) To darken a blue sky with a polarizing filter, the filter should be positioned

a. toward the sun.
b. 90° from the sun.
c. 180° from the sun.
d. 360° from the sun.

100. (269) Which of the following filter/film combinations would best penetrate a haze?

a. An infrared film and a red filter.
b. An orthochromatic film and an orange filter.
c. A red filter and a panchromatic film.
d. A panchromatic film and a yellow filter.

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CDC 23132

APPRENTICE STILL PHOTOGRAPHIC SPECIALIST

(AFSC 23132)

Volume 3

Processing and Printing of Black-and-White Materials

Extension Course Institute

Air University

Preface

THE THIRD volume of CDC 23132, *Apprentice Still Photographic Specialist*, is designed to help you qualify for the duties of a still photographer. Volume 3 contains information on film and print processing, printing, film and print finishing, and the storage and preservation of black-and-white sensitized materials.

Chapter 1 covers chemistry for black-and-white materials. This coverage includes the proper use of formulas, the chemical parts of the basic photographic solutions, chemical mathematics, chemical mixing units, and mixing procedures.

Chapter 2 presents procedures for the manual processing of black-and-white sensitized film emulsions and the type of equipment that may be encountered.

Chapter 3 deals with black-and-white film finishing. Here we cover washing, drying, etching, spotting, and opaquing. In addition to describing the procedures used to apply these finishing techniques, we also explain the need for archival quality and the handling and storage of processed negative materials.

In Chapter 4 we discuss the emulsion characteristics of black-and-white sensitized print materials and the various methods and procedures required for the proper storage and preservation of these materials.

Chapter 5 covers the basic points of photographic printing. We discuss the various methods of printing and the techniques used in the production of quality prints. In addition, we elaborate on the types of printing equipment that may be encountered and how they are used.

In Chapter 6 we present information for the processing of black-and-white print materials. The discussion deals with solution chemistry, processing controls, and the requirements for good darkroom standards. Stabilization processing of print materials is also covered.

Chapter 7 discusses the finishing of black-and-white print materials. This discussion includes such items as mounting, spotting, and toning, as well as the application of protective finishes.

Code numbers appearing on figures are for preparing agency identification only.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTOX, Lowry AFB CO 80230. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

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This volume is valued at 30 hours (10 points).

Material in this volume is technically accurate, adequate, and current as of September 1975.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Conventional Chemistry for Black-and-White

THE MAIN function of the darkroom portion of the photographic process is to develop film and produce prints. The darkroom work would stop if there was no chemistry. It may be your job to insure that all chemicals needed for production are mixed and checked for quality. This is a responsibility that you cannot take lightly. An improperly mixed developing solution may cause an entire mission to be lost. Therefore, it is essential that you employ the utmost care when mixing, checking, or analyzing the photographic solutions used in your laboratory.

In this chapter we shall discuss basic principles in the preparation of black-and-white chemicals.

1-1. Following the Manufacturer's Instruction Sheet and Employing Chemical Formulas

It is regrettable how many technicians throw away the instructions upon opening a container of film, paper, or chemicals, when, by reading these instructions and following them, they could obtain consistent quality.

400. Briefly state why it is important to follow manufacturers' directions when preparing photographic chemicals.

Before you mix any photographic chemicals you should carefully read the manufacturer's directions. Much effort went into the production of the chemical product but it is only effective if it is used in the way that it was designed. The directions of even the most familiar product should be reviewed, as there are continuous attempts to upgrade photographic materials. For example, new film/developer combinations may call for changes in dilution, time, or temperature of solutions to get the required results. Following the directions is very important in the preparation of chemicals for both quality and safety reasons.

When working with photographic chemicals, you will be using either packaged or bulk chemicals. Packaged chemicals are your ready-mixed types. The directions normally require the thorough mixing of the package contents with water. The key to following packaged chemical directions is insuring that the right quantity of water at the required temperature is used. In addition, many packaged chemicals have more than one part. Each part must be mixed in proper sequence. Because packaged chemicals will probably meet all of your routine needs for developers, stop baths, fixing baths, toners, etc., it is important that you get into the habit of carefully reading the directions for preparing them.

Using bulk chemicals requires following a formula that tells you the various chemical ingredients that must be dissolved into water. Unlike most packaged chemicals, the use of bulk chemicals calls for very precise measurement of each ingredient. This requires both care and a knowledge of measuring in order to carry out the directions.

It is a good idea to keep a file of the various direction sheets. Such a file provides a quick reference for selecting the appropriate chemical for the job and is a good backup to have in case of loss of the original data sheet. An alternative source of information is the *Photo Lab Index* published by Morgan and Morgan, Inc. This publication contains a wealth of manufacturers' information.

Exercises (400):

1. Give two good reasons why it is important to follow manufacturers' directions when you are preparing photographic chemicals.

2. For packaged chemicals, you must add the right quantity of ______ at the required ______ .

3. For bulk chemicals, you must follow a formula, measuring each ______ precisely and usually dissolving them in a specified amount of ______ .

4. A file of various direction sheets serves as both a ______ and a ______ .

401. Apply principles of chemical mathematics to solve mixing problems.

The key to employing a photographic chemical formula is the ability to follow formula directions. This requires knowledge of chemical mathematics and measuring procedures.

The following is a typical Kodak Formula, presented to show you the basic format:

Kodak Developer D-13 (Tropical Process Developer for Films)

Water (125° F or 52° C)	24 ounces	750.0 ml
Kodak Elon	75 grains	5.0 grams
Kodak Sodium Sulfite, desiccated	1¾ ounces	52.5 grams
Kodak Hydroquinone	145 grains	19.0 grams
Kodak Sodium Carbonate (monohydrated)	2 ounces	60.0 grams
Potassium Iodide	30 grains	2.0 grams
*Kodak Sodium Sulfate, desiccated	1½ ounces	45.0 grams
Add cold water to make	32 ounces	1.0 liter

Dissolve chemicals in the order given.

Use without dilution. Develop 6 to 7 minutes at 85° F (29° C) or for proportionately longer times at lower temperatures. Rinse thoroughly for 30 seconds and immerse for 3 minutes in 5% formalin solution 37% formaldehyde, diluted: 1 part formaldehyde to 19 parts water). Then wash for 1 minute, fix 5 to 10 minutes in an acid hardening fixing bath (Kodak Fixing Bath F-5), and wash for 15 to 20 minutes.

Note the importance of having a warm water temperature for mixing. Warm water helps in dissolving the different chemicals. Following the mixing of the chemicals, it is important to cool the solution down to the processing temperature.

Chemical Mathematics. Solutions are prepared in terms of strenght. The strength of a photographic solution is identified in two different ways: percentage or parts. You need to know how to mix either type.

Percentage solutions. There are several common methods of making up a percentage solution. The one used in photography is to measure out the appropriate chemical in a parts-per-hundred ratio. For example, a 10-percent solution of sodium sulfite would require dissolving 10 grams of sodium sulfite per 100 cc of water.

Parts solutions. To prepare a parts solution, you must mix 1 unit of chemical with a specified number of units of water. These units can be of any weight from grams to pounds, provided that you measure all quantities in the same unit of weight or volume. For example, to mix a 1:2 solution of D-76 developer, you would mix 1 unit of stock D-76 solution with 2 units of water. The results are correct as long as identical units of measurement are used for each part of the formula (e.g., 16 ounces of stock solution with 32 ounces of water).

NOTE: The term "stock solution" identifies a concentrated chemical solution. A "working solution" is the solution used for processing. The working solution may be the same as the stock solution but more likely is a diluted stock solution, as given in the D-76 example.

Conversions. You may find it necessary sometimes to convert a parts solution to a percentage solution. Here is how you would proceed. In our example above, the D-76 developer consisted of 1 part of stock solution and 2 parts of water, making a total of 3 equal parts. To convert this ratio into a percentage, divide 100 by 3. The result is 33.3 percent. To say it another way, a solution of 1 to 2 is equivalent to a 33.3-percent solution.

Often the chemicals that you receive from your supply section are indicated by one type of measurement. To follow the directions of a particular formula, you may have to convert to another system. Table 1-1 shows the factors that you can use to make the conversions. For example, let's say that you receive a supply of sodium sulfite with the weight indicated as 5 pounds. However, your formula for a fixing bath calls for the addition of 2400 grams of sodium sulfite.

TABLE 1-1

CONVERSION FACTORS

TO CONVERT FROM	TO OUNCE	POUNDS	GRAINS	GRAMS
OUNCE	1.0	0.0625	437.5	28.3495
POUNDS	16.0	1.0	7000.0	453.593
GRAINS	0.002286	0.031428	1.0	0.64899
GRAM	0.35274	0.002205	15.4323	1.0

MULTIPLY BY FACTOR GIVEN ABOVE

OUNCES PER 32 FLUID OZ MULTIPLIED BY 29.96 = GRAMS PER LITER
POUNDS PER 32 FLUID OZ MULTIPLIED BY 479.3 = GRAMS PER LITER
GRAINS PER 32 FLUID OZ MULTIPLIED BY 0.06847 = GRAMS PER LITER
GRAMS PER LITER MULTIPLIED BY 0.03338 = OUNCES PER 32 FLUID OZ
GRAMS PER LITER MULTIPLIED BY 0.002086 = POUNDS PER 32 FLUID OZ
GRAMS PER LITER MULTIPLIED BY 14.60 = GRAINS PER 32 FLUID OZ

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*If it is preferred to use sodium sulfate crystals instead of the disiccated sulfate, then use 3½ ounces per 32 ounces (105 grams per liter).

You will want to know if the 5 pounds of sodium sulfite is enough to meet your requirements. Using table 1-1, you would multiply the number of grams in a pound, 453.593, by 5. Having done this, you can see that 5 pounds is equal to 2,267.965 grams. Therefore, you know that the 5 pounds of sodium solfite is not enough and that you must obtain an additional 133.035 grams.

Temperature conversions are another important consideration. If you need to convert Fahrenheit into Centrigrade, subtract 32 from the degrees Fahrenheit, multiply the difference by 5, and divide the product by 9. For example:

$100^\circ \text{ F} = x^\circ \text{ C}$

$(100 - 32) \times 5 \div 9 = x$

$68 \times 5 \div 9 = 37.77$

$x = 37.8^\circ \text{ C}$

On the other hand, if you desire to convert Centigrade into Fahrenheit, multiply the Centigrade edegrees by 9, divide by 5, and add 32 to the result. Here is an example of what we mean:

$100^\circ \text{ C} = x^\circ \text{ F}$

$100 \times 9 \div 5 + 32 = x$

$900 \div 5 + 32 = x$

$180^\circ + 32 = 212$

$x = 212^\circ \text{ F}$

Exercises (401):

1. How should you mix 100 cc of a 25-percent solution of hydroquinone?

2. How should you make a 1:3 working solution of D-72?

3. 68° F is equal to how many degrees Centigrade?

4. 50° C is equal to how many degrees Fahrenheit?

5. A 1:4 solution of D-19 is equal to what percentage of D-19?

402. State principles, procedures, and facts related to chemical measuring.

Mixing Accuracy. Photographic quality control suffers if the chemicals are mixed in improper amounts. You must be certain that the amount of chemical you put into a solution is the amount specified in the formula. Therefore, you must use accurate measuring devices such as chemical weighing balances and graduates.

Chemical weighing balances. There are two general types of chemical weighing balances in use throughout the Air Force: the metric and the avoirdupois. The metric balance is used to measure milligrams, grams, or kilograms, whereas the avoirdupois balance is used to measure grains, ounces, and pounds. When you are weighing chemicals for mixing, the type of balance to use depends on the unit of weight measurement called for in the formula. If, for example, the formula asks for a specific number of grams, you should use a metric balance. If, on the other hand, the formula calls for a specific number of grains, you should use the avoirdupois balance.

As important as choosing the correct type of balance for your chemical weighing is using a balance of the correct capacity for the job. For example, one typical developer formula may call for 5.0 grams of potassium bromide per liter of solution. If you use a large-capacity balance capable of measuring hundreds of grams with an accuracy of ±1.0 gram, the amount of chemical weighed out for the solution could be as little as 4.0 grams or as much as 6.0 grams. Such variation from the exact, desired amount of chemical can radically alter the characteristics of the developer and would, at the very least, seriously affect the batch-to-batch uniformity. When choosing a balance for chemical measurement, always apply the rule that the smaller the quantity to be weighed, the greater must be the accuracy of the balance. Small quantities of chemicals—500 grams or less (or 1 pound or less)—are best weighed on a balance that is accurate to 0.1 gram (or 1 grain). Weigh large quantities on larger-capacity balances having a proportionate degree of accuracy.

Figure 1-1 illustrates a typical chemical weighing balance. This is a balance used for weighing quantities of chemicals from 0.1 gram to 210 grams (1.54 grains to 0.46 pound). This balance has a maximum capacity up to 2 kilograms when supplementary weights are used. There are larger balances, which allow you to weigh chemicals in much larger quantities, but we shall use the balance in figure 1-1 to illustrate the principles that apply to nearly any type of balance.

The balance shown in figure 1-1 is essentially a lever with equal arms on either side of the beam bearing (or fulcrum). Weight is added to the right arm of the beam in known quantities. The chemical to be weighed is then added to the left arm until the weights balance.

Some balances, such as the one shown in figure 1-1, have sliding weights mounted upon a calibrated scale on the beam. Moving the sliding weights from left to right increases the weight on the right end of the beam. Study figure 1-1 and notice that the upper sliding weight can be positioned from 0.0 gram to 10 grams in increments of 0.1 gram. The lower sliding weight can be positioned from 0.0 gram to 200 grams in increments of 10 grams. When using a combination of the two sliding weights, you have a range of 0.0 gram to 210 grams in increments of 0.1 gram.

Many balances do not have calibrated sliding weights but are supplied with individual weights of varying sizes. These could range from 1 gram to 10 pounds, etc., depending on the particular balance.

The heart of the beam balance is the bearing surface that supports the beam. Since friction at this point must be held to an absolute minimum in order to give you accurate measurements, this bearing arrangement is critical and delicate and will not stand any abuse. You must give the chemical balance the same care as that given to any extremely delicate precision instrument.

Pans are used on the balance arms to hold the material that is being weighed. The pans are also used to hold the weights when separate weights are used for making the measurement.

A balance indicator on the beam balance shows when the material that is being weighed and the calibrated, counter-balancing weights are equal. In the balance shown in figure 1-1 the indicator consists of a scale and pointer. You may find in other balances that the indicator is composed of two extensions over the center of the beam which are part of the pan supports. A state of equilibrium is indicated on this type of balance when these two extensions are aligned.

The beam balance is equipped with a balance adjustment or trimming device. This adjustment, consisting of movable weights, can be positioned and locked to compensate for minor inequalities in the weights of the two ends of the beam that could, if not corrected, give you erroneous readings.

Since you must use scale balances for chemical mixing, let's discuss their operation. Refer to figure 1-1 as you follow the explanation.

When you want to weigh a specified amount of material to fulfill the needs of a formula, operate the scales in the following manner:

(1) Set the sliding weights to that they indicate the correct weight as specified in the formula. If you are using a balance with separate weights, place them in the right-hand pan. Doublecheck your settings.

(2) Slowly add the chemical being weighed to the pan on the left. Make it standard practice to use paper on the balance pans. Paper protects the balance pan and also minimizes contamination of the chemicals that are being weighed. Use an equal-size sheet of paper on both pans so that the overall trim of the beam is not altered appreciably. If an imbalance occurs, the balance adjustment can be used to compensate for it.

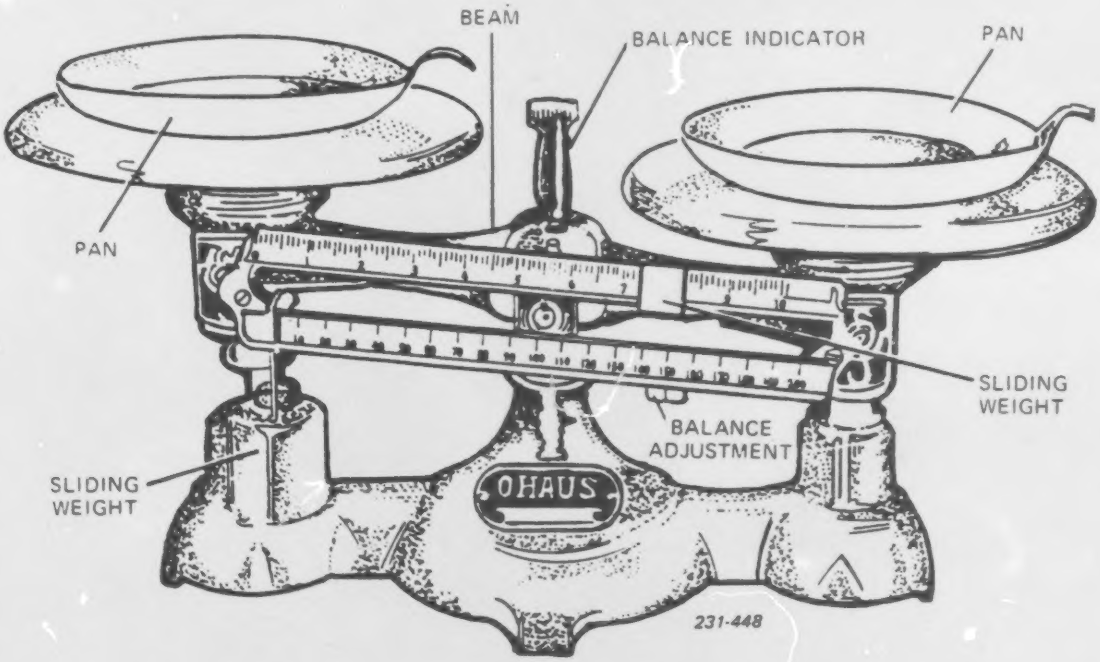

Figure 1-1. Chemical weighing balance.

(3) Add the chemical until the balance indicator shows tnt the weight of the chemical is the same as the scale weights. (If the chemical is in a large container, use a ladle or spoon for transferring the chemical to the balance in order to prevent excess chemical from spilling onto the pan.)

(4) Remove the weighed chemical from the left pan by picking up the paper and then pouring the contents into the solution you are mixing. After adding the chemical to the solution, carefully discard the paper in such a manner that any finely powdered chemicals do not become airborne.

(5) Put a fresh sheet of paper on the left pan before weighing the next chemical. Be sure to retrim the balance each time you change the paper in order to avoid introducing an error into the weight of the next chemical that is weighed.

If you have a quantity of chemical and wish to find out its weight, then use the following procedure:

(1) Place the chemical to be weighed in a fresh paper on the left pan, making sure that the balance has been trimmed for the fresh sheet of paper.

(2) Starting with the sliding weights on their "0" settings, slowly increase the weight until the balance indicator shows a state of equilibrium. If you are using a balance that uses separate weights, add the weights to the right-hand pan.

(3) Determine the weight of the material by adding up all of the weight that has been added to the right end of the beam (i.e., by adding the values of the sliding weights and any separate weights in the right-hand pan).

Regardless of the type of balance that you use in weighing your chemicals, there are certain precautions you should always observe. Avoid handling the small weights with your fingers, since perspiration and oil on your hands could change the true weight of the smaller weights and cause inaccurate measurements. Perspiration may also eventually cause corrosion of the weights and make them heavier than they should be. Handle all small weights with a pair of tweezers. Always weigh the chemicals in the order that they are given in the solution formula. By following the established order, you are less likely to omit any of the ingredients. Furthermore, some chemicals will precipitate if mixed in the wrong order.

Photographic graduates. Besides using balances for measuirng dry photographic chemicals, you will also use photographic graduates for measuring liquids. You would, e.g., use the graduate for measuring the amount of sulfuric acid to put into a bleach solution.

Graduates are made in varying sizes, calibration, and construction material. Figure 1-2 illustrates two common types of glass graduates. Although most of the graduates you will use are calibrated in the U. S liquid measurement system (drams, ounces, quarts, and gallons), it is not uncommon to find a graduate calibrated in the metric liquid measurement system (liters).

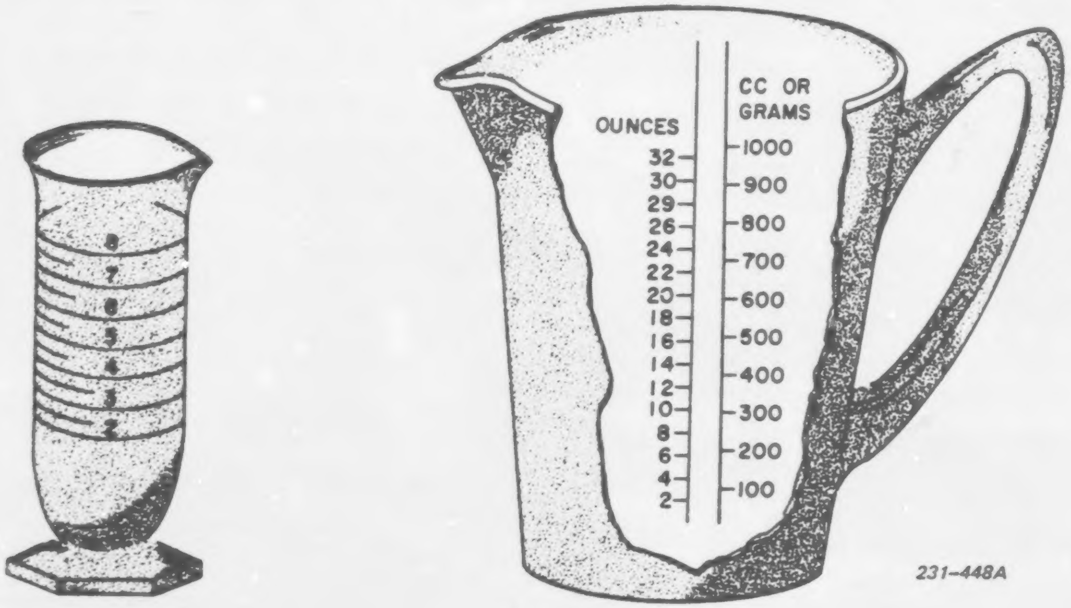

Figure 1-2. Photographic graduates.

Glass is most commonly used for making graduates because it is inert to most chemicals, transparent, and reasonably durable. Graduates are also made from other materials, such as plastics. When using graduates of plastic, be sure that you do not try to measure strong acids such as sulfuric acid, which could cause severe damage. You should also make sure that the material of the graduates you use does not react with any of your photographic chemicals.

To use the graduate, slowly pour into it the liquid to be measured. Stop pouring when the upper surface of the liquid reaches the calibration mark indicating the desired amount. Major divisions are indicated by numerals on the glass. Subdivisions are indicated by calibration lines only. You must compute the value of the individual subdivisions. For example, the marked lines may read in series of 10. If there is only one calibration line between each graduation of 10, then the calibration line would be for a value of 5.

Exercises (402):

1. The beam balances you are likely to use will probably be calibrated for what two weighing systems?

2. In terms of accuracy, what is the rule for choosing a balance?

3. Complete the following statements on the operation of a beam balance.

   a. A beam balance uses either ______ or ______ weights.
   b. ______ should be placed in each pan to prevent contamination.
   c. Inequalities between the two ends of a beam is corrected by using the ______ device.
   d. Chemicals to be weighed are placed in the ______ pan.
   e. When individual weights are used, they are placed in the ______ pan.

4. What should be your main concern when you are considering the use of graduates made of different materials?

5. If there are four calibration marks between the 0 and 10 marks on a graduate, each calibration mark would stand for how much of an increase?

1-2. Using Packaged Chemicals

The majority of your chemical needs are going to be met through the use of packaged chemicals. You should, therefore, become very familiar with their use.

403. State facts and procedures related to the use of packaged chemicals.

In the production of packaged chemicals the manufacturer has mixed in all the ingredients. Normally, you need only add the package contents to water. There are two basic categories of packaged chemicals: formula and proprietary. The formula type, like D-72, contains the same ingredients as found in published formulas. The formulas for proprietary developers, such as Kodak's Dektol, are not published. Packaged chemicals are easy to store, handle, and mix. They provide consistent quality.

Packaged chemicals are available to cover all your photographic needs. You can order preparations for developers, stop baths, and fixing baths, as well as toners, reducers, intensifiers, and the like. There are a number of different photo chemical manufacturers, and you will have a wide selection within the context of the Federal supply system. Always keep in mind that you should choose chemicals that are compatible with the films and papers that you are using.

The preparation of packaged chemicals requires mainly that you follow the directions carefully. Premixed chemicals may be in powder or liquid form. There may be several parts in the package that must be mixed in a certain manner. Typically, the contents of the package are to be mixed with a specific quantity of water. The water must be at the prescribed temperature. The majority of packaged chemicals are mixed in warm water, but read the instructions to make sure. (Remember that the temperature for mixing may not be the same as the processing temperature, so you may have to wait for the solution to cool to the correct temperature for use.) When there is more than one part, make sure that the parts are added in the correct order. Do not be in such a rush that you fail to follow directions.

Remember to follow the proper procedures for chemical safety. You should prepare the chemicals in a well-lighted and ventilated room. Do not taste or inhale any chemical. You should wear rubber gloves, apron, and mask for your personal protection. Remember, for safe mixing and quality results, follow directions.

Exercises (403):

1. What are the two types of packaged chemicals?

2. State four advantages offered by packaged chemicals.

3. What is the most important rule to keep in mind to insure consistent results when using packaged chemicals?

4. In what type of environment should package chemicals be prepared?

1-3. Using Bulk Chemicals

An alternative to packaged chemicals is preparing your solutions by using available formulas (found in the *Photo Lab Index,* etc.) and bulk (i.e., raw) chemicals. In this section, we shall briefly cover the use of bulk chemicals.

404. Explain the reasons for using bulk chemicals and state nomenclature and procedures related to the use of bulk chemicals.

Mixing solutions by referring to published formulas (in the *Photo Lab Index,* etc.) and using bulk chemicals can be advantageous. You can prepare solutions you rarely use (e.g., toners) or those which are not available in premixed form. When you have bulk chemicals on hand, you may be able to meet special mission requirements.

Chemical Grades. It is important when using bulk chemicals that you are aware of the standards of chemical quality. The United States of America National Standards Institute (USANSI) publishes a series of standards covering all of the chemicals used in photographic processes. These USANSI standards contain specifications that establish the degree of purity and state limiting concentrations for potentially harmful impurities that may be present. You can prevent faulty processing caused by the use of chemicals of inferior quality by using only a grade of chemical that meets or exceeds these USANSI standards.

Chemicals such as sodium sulfite, sodium carbonate, hydroquinone, Metol, etc., which are used in large quantities by the photographic industry, are designated as "Photo Grade" by most suppliers of chemicals. This designation means that the chemical so rated meets the USANSI specifications for photographic grade chemicals. "Photo Grade" or a similar designation is not, however, one of the standard designations of chemical purity commonly used by chemical manufacturers. The quality designations most often used are given below with a brief definition of each.

- Primary Standard: A specially manufactured and tested analytical reagent of exceptional purity. Used exclusively for standardizing laboratory volumetric solutions and preparing reference standards.
- ACS or Reagent Grade: A chemical that fully meets the requirement of the American Chemical Society for Reagent Grade chemicals. Used in analytical laboratories for testing and evaluating other chemical preparations.
- C.P.: Chemically pure grade, generally exceeding U.S.P. or N.F. requirements, but slightly lower quality than Reagent Grade.
- U.S. P.: A grade meeting the requirements of the United States Pharmacopoeia (i.e., medicine).
- N.F.: A grade meeting the requirements of the most recent, or designated, issue of the National Formulary. (U.S.P. and N.F. Grade chemicals are primarily for drug use.)
- Purified: A grade of higher quality than Technical, often used where there are no official standards.
- Technical: A grade suitable for general industrial use.

Generally speaking, USANSI photographic grade chemicals are within the quality range of the U.S.P., N.F., and Purified grades. C.P. Grade chemicals are always suitable for photographic use but are of a higher quailty (and cost) than is generally required. Reagent Grade and Primary Standard chemicals are very costly and are much purer than is required for photographic purposes. Some Technical Grade chemicals are satisfactory for photographic use. Their low price and availability make them desirable, but for precise photo applications, they should be thoroughly evaluated before use.

Prior to using chemicals of unknown grade, you should obtain the USANSI specifications for the particular chemicals in question and perform the laboratory tests as given in these specifications. Chemicals failing to meet the given purity limits should not be used in preparing photographic solutions.

Bulk Chemical Storage and Procedures. Bulk chemicals should be kept in appropriate dark (amber, etc.) stoppered bottles or jars for proper keeping in a cool, dry place away from sensitized materials. All containers should be properly labeled, as many chemicals are poisonous. Maximum safety can be insured by keeping all the toxic chemicals in a locked cabinet to which only authorized personnel have access.

To take advantage of bulk chemicals, you need a properly stocked chemical mix section. An accurate balance, graduates, thermometer, and stirring rods are a few of the basic items that are required. Personnel who mix chemicals should be thoroughly trained in proper procedures, including reading a formula, using mixing equipment, and observing proper chemical safety practices.

You are perhaps tired of being continually reminded about chemical safety, but it must be stressed over and over again with the hope that you will make it a habit in your work. Any accident brings hardship to everyone in the section. To this end, here is another review of basic safety procedures that are particularly applicable when you are using bulk chemicals.

- Never smell a chemical directly from the bottle. Instead, hold the bottle at a distance from your nose, and sniff its contents cautiously rather than inhale directly.
- Never taste a chemical.
- Handle all chemicals cautiously: many will produce burns or skin irritation.
- When mixng a strong acid with water, add the acid slowly to the water while stirring continuously; otherwise, the solution may boil violently and splatter on your hands and face, causing serious burns. Remember: *Never pour water into acid.*
- Be sure that the chemical mixing room or area in which you are going to mix chemicals is well-ventilated. The fumes or dust from some chemicals can be very irritating to your nose and eyes, as well as harmful to photographic sensitized materials.
- In all cases, be sure to see a doctor as soon as possible in the case of an accident.

Exercises (404):

1. What are the advantages of using bulk chemicals?

2. What grade of chemical is normally used in photographic work?

3. Under what circumstance can you use Technical Grade chemicals for photographic work?

4. How should bulk chemicals be stored?

5. What type of facilities do you need in order to use bulk chemicals?

6. How should acid and water be mixed? Why?

1-4. Chemical Mixing Units

In the Air Force, we use two methods of mixing chemicals: (1) hand mixing and (2) machine mixing. Hand mixing is employed when only small quantities of solutions are needed or when machines are not available. Machine mixing is necessary to handle the large production requirements of most labs. In this section we shall point out the operation of the A-1 mixer, which is typical of the mixing units you will be using.

405. Indicate nomenclature and procedures related to the operation of the A-1 mixer.

A-1 Mixer-Distributor. The A-1 mixer-distributor, shown in figure 1-3, is designed for mixing chemical solutions and distributing the batch to the point of use. While the A-1 mixer will mix 50 gallons of chemicals at one time, it has the advantage of being mounted on coasters, allowing you to mix the chemicals in one location and then wheel the mixture to another location for distribution.

The mixer operates by using a series of valves and a pump. Two valves, similar in construction, are located on the control panel, shown in figure 1-4. Opened and closed by rotating the handles, they interconnect the IN hose coupling (valve B) and the OUT hose coupling (valve A) when in the closed position. If the valves are in the closed position, the solution in the mixing tank circulates through the pump and back into the mixing tank.

Prior to operating the mixer, you need to connect the hose with the gooseneck to the coupling marked "OUT," located on the extreme left side of the control panel. Next, connect the second hose to the coupling marked "IN," on the extreme right side of the control panel. The next step is to suspend the calibration dipstick from the inside lip of the tank. The dipstick is calibrated in gallons for solution measurement.

Pump purging. Before the pump can operate efficiently, air must be purged from the system as follows:

(1) Open valves A and B 1/4 of a turn.
(2) Pour 3 gallons of water into the tank.
(3) Position the switch at low speed and allow the mixer-distributor to operate for a long enough period to circulate the water through the pump.

Tank filling. To fill the mixer-distributor tank, proceed as follows:

(1) Purge air from the pump.
(2) Submerge the inlet accessory hose into the solution supply tank.
(3) Open valve A and close valve B.
(4) Turn the power switch to high.

Mixing solution. To mix your chemicals, fill the mixer with the required amount of water at the appropriate temperature and then open valves A and B. Turn the power switch to high. The water will be drawn through an outlet in the bottom of the mixing tank, circulated through the pump, and then pumped back into the mixing tank.

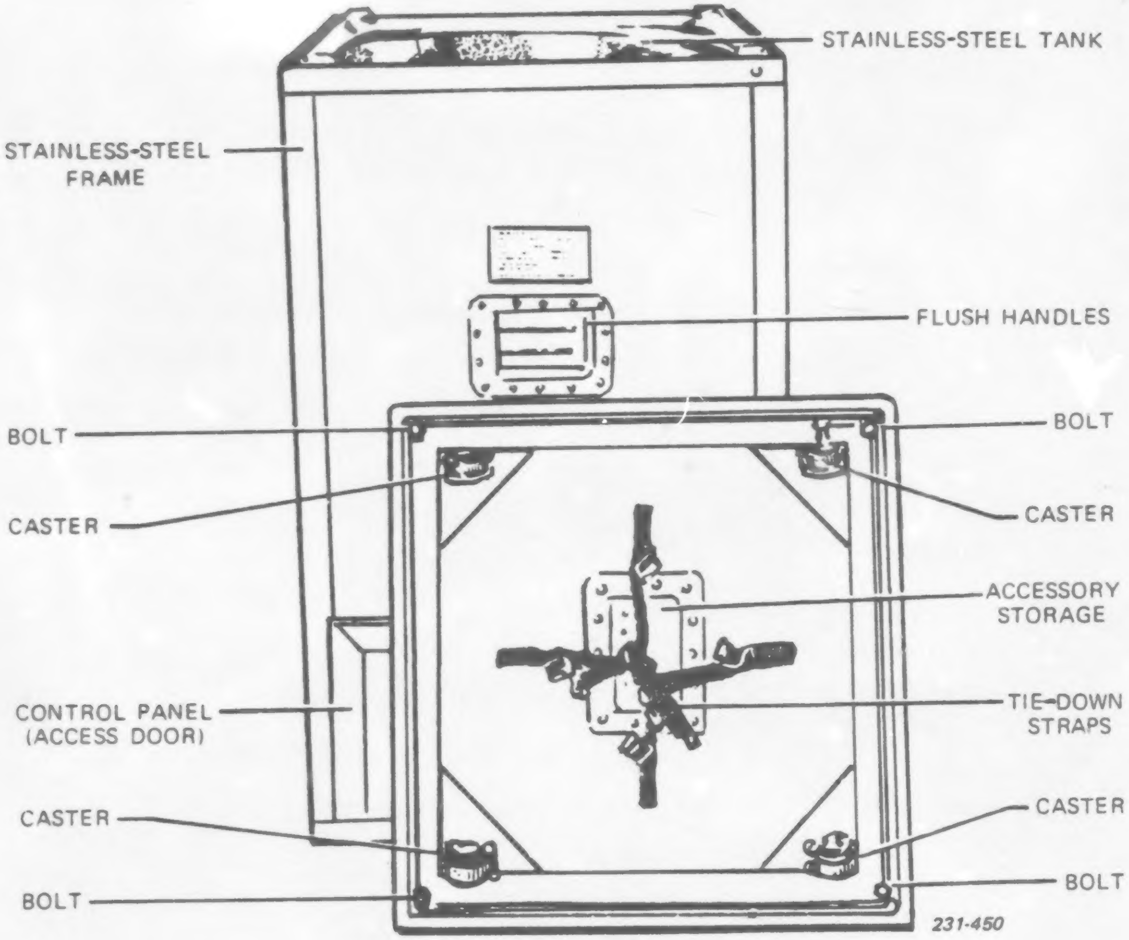

Figure 1-3. A-1 mixer/distributor.

Once you are sure that the water is circulating (this is indicated by motion of the water), add the chemicals in the order specified in the formula or mixing instructions. Be sure to break up any large lumps of chemicals into small pieces in order to insure mixing. When pouring the chemicals, hold the chemical container close to the surface of the water. This technique cuts down on dust and prevents splashing.

During mixing, you may find it necessary to dislodge undissolved solids on the bottom of the tank. To do this, stir the solution with a long stirring rod or chemical mixing paddle. The occasional stirring insures that all chemicals are being dissolved into the solution.

After all your chemicals have been dissolved, add cold water to bring the solution to its final volume.

Distributing mixed solution. Distribute the mixed solution as follows:

(1) Place the gooseneck on the outlet accessory hose over the edge of the working or storage tank to be filled.

(2) Close valve A.

(3) Open valve B.

(4) Position the power switch at high speed and allow the mixer-distributor to operate until the working or storage tank is filled.

Recirculating mixed solution. To recirculate the solution through the mixer-distributor tank and the working or storage tank, proceed as follows:

(1) Submerge the inlet accessory hose into the working or storage tank containing the solution to be recirculated.

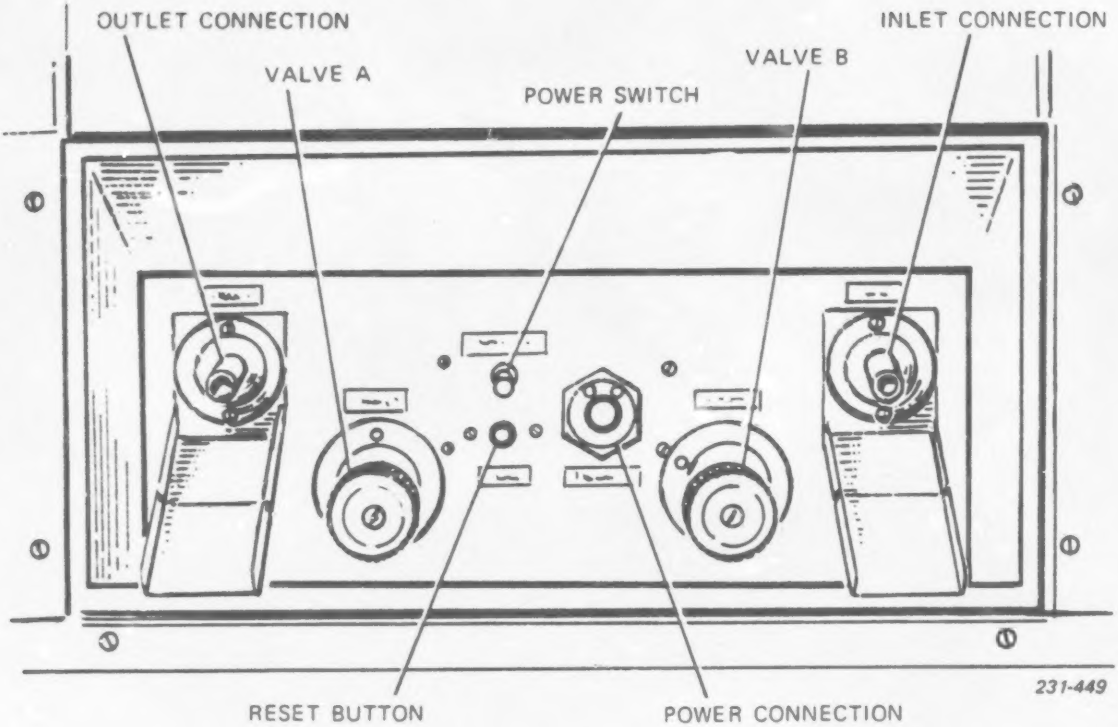

Figure 1-4. Control panel of the A-1 mixer.

(2) Place the gooseneck on the outlet accessory hose over the edge of the same tank in which the inlet hose is submerged.

(3) Turn both valve handles to a position halfway between full clockwise and full counterclockwise.

(4) Turn the switch to high speed and allow the mixer-distributor to operate until the old solution is mixed with the new.

Transferring solution. To transfer solution from one working or storage tank to another, proceed as follows:

(1) Purge air from the pump.

(2) Submerge the inlet accessory hose into the working or storage tank containing the solution to be transferred.

(3) Place the gooseneck on the outlet accessory hose over the edge of the tank to which the solution is to be transferred.

(4) Close both valves.

(5) Position the switch at high speed and allow the mixer-distributor to operate until the solution is transferred.

NOTE: Be sure to check the appropriate operating instructions for the mixer that you are using. This precautionary action will insure safe quality operation.

Exercises (405):

Complete the following statements on the operation of the A-1 mixer.

1. You can mix up to ______ gallons in the A-1 mixer.
2. The IN hose coupling is controlled by ______ .
3. Prior to operation, the pump should be purged of ______ .
4. When the A-1 mixer is mixing chemicals, its valves are ______ .
5. Both valves are in an intermediate position when ______ mixed solution.

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Black-and-White Film Processing

AS AN AIR FORCE photographer, you must realize that the composing and exposing of a scene is no assurance of a top notch photograph. The quality of the finished print is dependent to a great extent on the quality of your darkroom work. A perfectly exposed negative is useless if it is fogged, scratched, or reticulated during processing. It is, therefore, very important that you master the very important step of film processing.

2-1. Basic Information on Cut-Roll-Pack Processing

The correct choice of the appropriate film processing method depends upon the type of film to be processed and the type of processing equipment that is available. However, before we get into details regarding the different methods, it is important to get a clear overall view of the five basic processing steps and the main types of film.

406. Briefly explain the purpose of the five basic processing steps.

Basic Processing Steps. The five basic processing steps, as shown in figure 2-1, are development, rinsing, fixing, washing, and drying. It is important to consider what takes place in each step of processing. If you know the purpose of each step, you can understand different processing methods and can identify the causes of processing problems you might have.

Developer. The action of the developing solution is to produce density in those areas of the film that have been exposed to light. This involves the reduction of the exposed silver halides to black metallic silver. For a given amount of development, the more exposure the film received, the darker it will appear upon processing. It is most important that this step be done correctly for it is this step that transforms the latent image into a useful one. If you develop too little, you will not retain all the detail you exposed for; if you develop too long, you could reduce unexposed silver, thereby causing fog.

Rinse. Once the film has been through the development step, it is drained and then placed into the rinse. The rinse consists of plain water. The water rinse lowers the concentration of the developing chemicals and considerably reduces the action of the developer. A common alternative to the plain water rinse is a stop bath, which is a mixture of water and acetic acid. The action of the acid neutralizes the action of the developer. The purpose of the rinse or stop bath is to retard or stop development, preventing overdevelopment.

Fixing. The function of the fixing bath is to make it possible to remove the light-sensitive silver compounds or exposed silver compounds that have not been developed. If these compounds are allowed to remain, they will fade when exposed to light. This step is, therefore, essential in order to insure a permanent image.

Wash. Film is then washed in fresh water to remove all the chemical concentrations that might be remaining within the film. If sufficient concentrations of chemicals are allowed to remain, they may discolor with time.

Drying. The final step in processing is to dry the film. This action permits the gelatin to harden and makes the negative durable enough to be handled with little danger of damage during the printing process.

Exercise (406):

1. Briefly explain the purpose of each of the basic processing steps.

407. Distinguish between the different types of film processing procedures.

As illustrated in figure 2-2, you are likely to encounter a number of different types of films to process. Except for Polaroid, which has a "built-in" processing system, you should be able to hand process all of the other kinds. These types can be broken down into two broad types: sheet film (individual cut pieces of film normally available in sizes like 1¼ x 3¼", 4 x 5, 5 x 7, 8 x 10, etc.) and roll film available in sizes like 35mm, 120, 70mm, etc.). Let us now get a brief overview on how these types are processed. We shall be going into more detail later in this chapter.

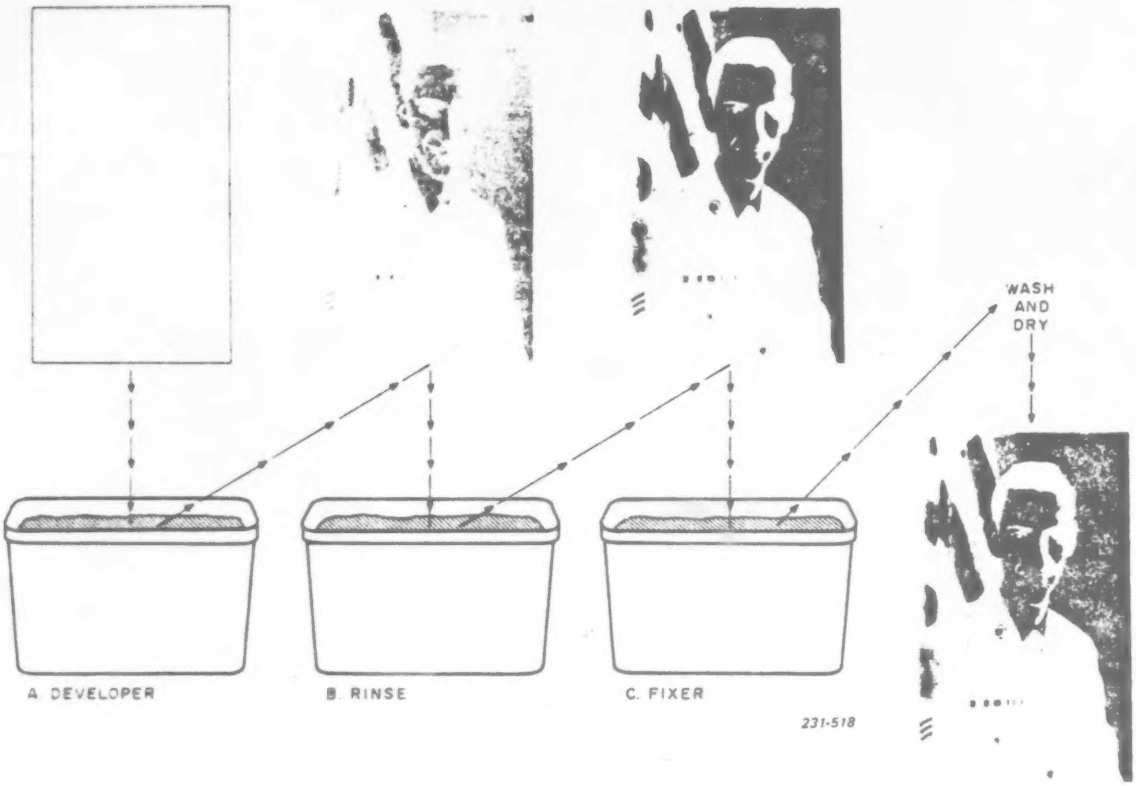


Figure 2-1. Film processing.

Sheet (Cut) Film. Sheet films may be processed in either trays or tanks. Although tray processing is satisfactory, it is recommended only for small amounts of film. Normally, tank processing is more uniform for large numbers of sheets. With this method, each sheet of film is retained in a hanger, which is placed into a tank. Regardless of the method used, great care in handling is necessary in order to prevent scratches and to insure even processing from sheet to sheet.

Pack Film. The development of pack film is accomplished in the same manner as that prescribed for sheet film. However, the individual sheets of film are quite thin and therefore tricky to handle.

Roll Film. Roll film is processed by using reels and tanks. The film is wound onto a spiral reel. The reel is then placed into a tank for processing. The key to getting started is winding the film onto the reel in the proper manner.

Exercises (407):

1. What is the most common method of processing sheet film?

2. How is roll film processed?

2-2. Safelights

Now that we are starting to get into darkroom operation it is important to understand the purpose of safelights. It may come as a surprise to you that not all darkrooms are "dark." Depending upon the material that is being handled, it may be possible to have lights on. These lights are called safelights.

408. Identify principles, procedures, and nomehclature associated with safelights.

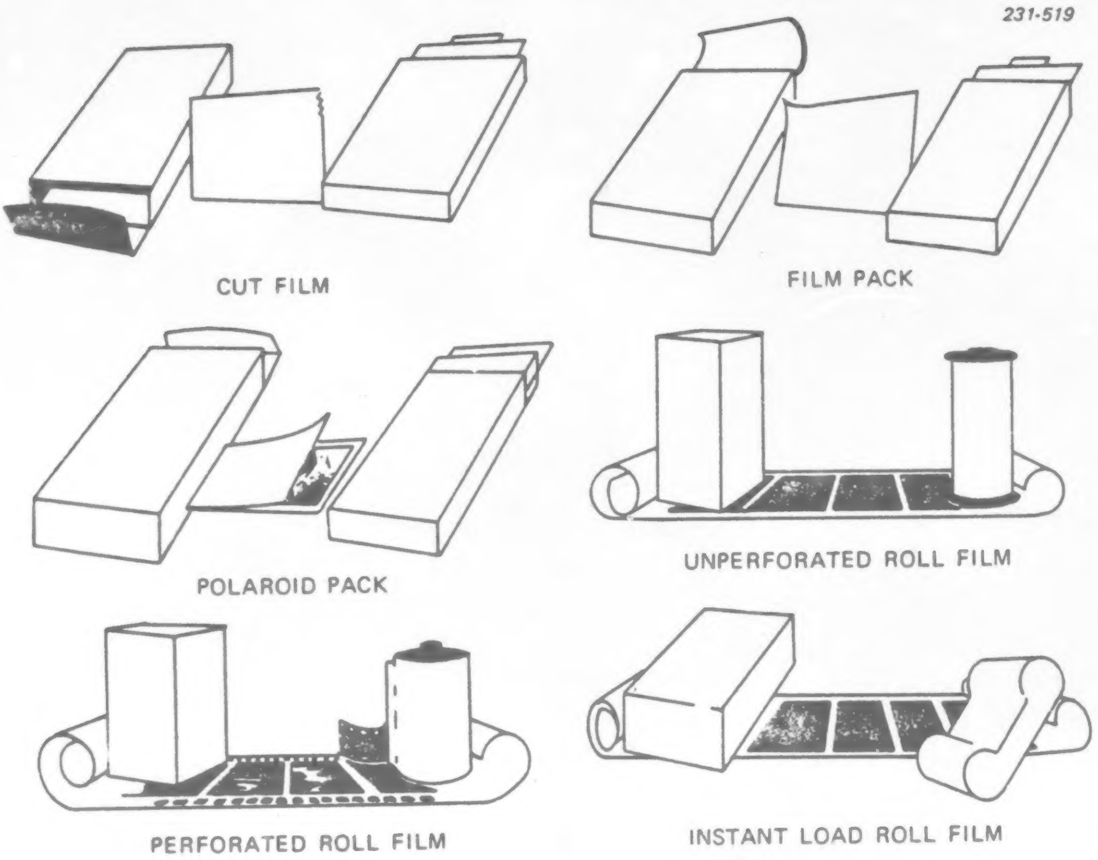


Figure 2-2. Film packaging.

The function of a safelight is to transmit the maximum amount of light that can be used safely without damage to the sensitized materials being handled. Since the color sensitivity of different photographic materials varies, the color and intensity of the light must vary accordingly to be safe. Therefore, a photographic laboratory safelight is a combination of a rated light source and the designated filter to protect a specific sensitized material.

The following list of safelight filters are the ones most commonly used during black-and-white film processing (the numbers are Kodak Wratten designations):

Filter No.	*Color*	*Use*
1	Red	Blue sensitive films.
1A	Light Red	Orthochromatic copy films.
2	Dark Red	Orthochromatic film.
3	Dark Green	Panchromatic film.
7	Light Green	Infrared film.

When using a safelight, keep the following in mind:

- Install only the size of incandescent bulb specified by the manufacturer. If you use too large a bulb, the heat may damage the safelight filter or be too bright to be safe.
- Make sure that the safelight is properly grounded and that any wiring is kept far away from the processing solutions.
- It is important that the proper distance be established between the safelight and the processing area. Consult the manufacturer's instructions for proper placement.
- The film must be handled under the safelight in the correct manner. (For example, for processing panchromatic film, the use of the green safelight may be limited to intermittent use or to use only after several minutes of processing in total darkness. As always, follow directions in order to insure quality results.)

It is a good idea to perform periodic safelight tests to make sure that your materials are not fogged. The test can be performed in the following manner:

(1) Place a sheet of unexposed film on a working surface in the processing area.

(2) Place one or more small opaque objects (e.g., coins) on the emulsion and, with the safelights on, leave the film for twice the time that it would normally be handled.

(3) Process normally and check to see whether there is less density in the areas covered by the opaque objects. Less density would indicate fogging of the film by the safelight.

A safelight that causes fogging can be corrected by replacing the filter, installing a lower-rated bulb, or increasing the distance between the safelight and the material.

Exercises (408):

1. What is the purpose of a safelight?

2. Match the appropriate safelight filter number in column A with the appropriate film in column B.

Column A	*Column B*
___ a. 1.	(1) Orthochromatic film.
___ b. 2.	(2) Infrared film.
___ c. 7.	(3) Blue sensitive film.
___ d. 3.	(4) Panchromatic film.

3. Why is it important not to use too bright a bulb with a safelight?

2-3. Using Trays

Sheet film, pack film, and, in rare cases, roll film can be processed by using trays. The tray method is particularly convenient for processing a few sheets of film having the same size. In all cases, tray processing requires the most direct handling of the film, thereby requiring the greatest care to prevent scratches and insure uniformity. In this section we shall discuss the procedures for tray processing.

409. Explain procedures involved in processing sheet film by the tray method.

Darkroom Requirements. Every laboratory should have a standard rule of having a place for everything and keeping everything in its designated place. This is important both for finding equipment in total darkness and for moving about safely within the laboratory.

Sinks should be large enough to handle the trays that are used for processing. If sinks are properly designed, they will drain completely when the stopper is removed. A wooden duckboard grating is helpful for keeping the trays off the bottom of the sink. It will do much to prevent damage to both the sink and the trays.

Aprons (preferably waterproof) should be worn to protect clothing, and when soiled, should be given a thorough cleaning. Chemically clean towels are necessary for wiping the hands. It should be standard practice to have a towel handy when you process materials.

You should start with spotlessly clean trays to prevent contamination by corroded processing chemicals. Trays are usually available in sizes running from 8 x 10 through 20 x 24. Trays with a raised X on the bottom surface are ideal for the developer solution, as the film has its greatest tendency to stick to the bottom of the tray in the developing solution. Normally, the trays are arranged from left to right in the following order: presoak, developer, stop bath, fixing bath, and wash. If only one or two sheets of film are to be processed, the presoak may be omitted.

The trays should be filled with the appropraite chemicals or water. It is very important that all solutions be properly mixed and at the correct processing temperature. The trays should be full enough to insure complete immersion and ease of handling. For the wash tray, it is a good idea to have a continuous flow of water available.

When the solutions are ready, place a dry, dust-free paper or cardboard on the workbench near the presoak. Place the film holders to be unloaded near this clean working space. Set the timer for the correct developing time, and place it in a convenient location on the workbench or table near the processing solution. Then turn out all but recommended safelights.

Developing Sheet Film. Remove one sheet of film from its holder and place it emulsion down on the paper or cardboard. Continue this process until all the sheets to be developed have been placed in a loose pile on the space provided for them. However, as stated earlier, do not attempt to develop more than a few sheets at a time.

Submerge the films one at a time into the presoak, which should have the same temperature as the other processing solutions. NOTE: Presoaking the film in water prevents the sheets from sticking together in the developer. If sticking occurs, it causes streaks and uneven development. Presoaking also helps the developer to diffuse evenly into the emulsion. However, it does cause a slight increase in the time reqired for normal development because complete saturation of the emulsion by the developer is delayed. Compensation for this increase in time should be made when determining the developing time.) To submerge the films, pick up the sheet on top of the pile with the left hand (keep the left hand dry until all films have been placed in the water), drop it emulsion side down into the water, and immerse it quickly with the right hand. Pick the film up immediately, turn it over (emulsion up), and push it back under the solution. Slide the wet film to one end of the tray. Immerse the next film in the same manner. Stack it on top of the first film, and continue with this procedure until all the films are stacked in a pile at one end of the tray. The left hand should follow the last film into the tray to assist in the agitation of the film.

CAUTION: Wet film may be handled with wet fingers. However, take care to keep wet fingers off dry films.

Start the timer. Using the left hand, transfer each sheet emulsion up from the presoak into the developer. Slide the film under the surface of the solution quickly, and agitate it to eliminate any possible air bells. Note that it is important to keep track of each sheet by counting as you go through each step. This insures that the first sheet into a solution is the first one out.

The films are immersed emulsion side up in the developer to minimize the possibility of damage, which might occur if the emulsion, already softened by presoaking, is allowed to come in contact with the bottom of the tray. This also minimizes the chance of air being trapped and causing uneven development. It is important not to dig or drag the corner or edge of any subsequent films into the emulsion surface of the film below it. Do not allow the fingernails to dig the emulsion at any time. Stacking the films by aligning their edges against the sides of the tray helps prevent scratches and abrasions. Continuously agitate the film during the entire processing time by rotating each sheet from bottom to top.

About 10 seconds prior to the completion of the processing time, remove the first sheet, drain it, and submerge it into the stop bath (or rinse). Continue this process until all of the sheets of film have been transferred.

After all of the sheets of film have been rotated several times in the stop bath, they should be transferred individually to the fixing bath ("Hypo"). After agitating the sheets of film for several minutes in the fixing bath, you can turn on the white lights. Agitation at this point should continue on an intermittent basis until the total fixing time is up (5-10 minutes).

NOTE: It is necessary to rotate or agitate the film properly in both the stop bath and the fixing bath, because gases are released in these solutions due to the chemical reaction between the acid of these baths and the alkaline content of the developer. These gases can form gas bells on the film surface. Such bells can cause dark spots because of the continued action of the developer beneath them.

After fixing is completed, transfer the negatives to the wash water. Agitation should be continued unless a regular film washing tank or tray is available. The negatives may be placed in the regular film hangers for washing in tasks when tray washing is not accomplished. Washing the film in running water should be continuous for a period of 10 to 30 minutes. Most film manufacturers recommend that film be washed for at least 20 minutes. However, this time is only approximate, since the amount of film and the rate of flow of the water determine the actual amount of time needed to wash the film sufficiently to insure adequate permanency.

NOTE: One key factor in tray washing is the complete change of the water. If the trays you use do not have a drainage system, it is important to hand change the water. This is necessary because chemicals tend to settle to the bottom of the tray because they are heavier than water.

Exercises (409):

1. Why is it important to have an orderly darkroom arrangement?

2. Why is it important to use clean trays?

3. Why is film presoaked prior to processing?

4. Why should you count the film as you go through each processing procedure?

5. Why must gas bells be prevented?

6. Why is it important to insure complete changes of wash water?

410. Explain procedures related to the tray processing of pack and roll film.

Processing Pack Film. A film pack is a metal container holding 16 sheets of cut film. Each sheet has one end glued to a sheet of black paper. The pack has a sheet tab attached to each sheet of paper, which permits the photographer to position each sheet into shooting position by pulling the tab. Once all the sheets have been exposed, the film is processed by using the same procedures as for regular sheet film, with these additional points to keep in mind.

- You need to practice the removal of film from the pack. This procedure requires the removal of a metal locking cover, which holds the two metal frames together. Once the top frame is separated, the stack of film may be taken out.

- You must carefully separate each sheet from its paper. This takes a little practice, as a beginner often has difficulty identifying which is paper and which is film.
- Pack film needs to be presoaked. Presoaking the film makes it easier to handle and will help in the removal of any remaining paper. It is, however, quite important to agitate pack film in the presoak to prevent it from sticking together.
- Throughout all procedures, it is important to exercise extreme care because pack film is *very thin*. It becomes slippery to handle and can be easily scratched. Also be very careful in counting each sheet, because it is surprisingly easy to leave one behind as you go from one tray to the next.

Developing Roll Film. Roll film can be processed by the tray method, using the same number of trays and solutions as used for cut films. The only difference in the procedure is the handling of the film.

You start by preparing the darkroom for tray processing, with the addition of two film clips. In total darkness with 120 roll film, unroll the paper backing (with 35mm, open the cassette and release the film) and fasten one of the film clips to one end of the film. Attach this film clip to a hook on a wall or darkroom shelf, about 6 feet above the floor, and slowly unwind the film while maintaining a slight tension. Separate the other end of the film from the paper backing and attach the second film clip.

Take the upper clip off the hook and allow the film to sag in a U-shape with the emulsion side down. Dip the bottom of the U into a presoak and pass the length of the film back and forth through the water by alternately lowering one end while raising the other. Continue agitating the film in this manner for about a minute. The presoak serves two purposes: it prevents the formation of air bells when the film is placed in the developer and it greatly reduces the tendency of the film to curl.

Turn the film over, emulsion side up, start the timer, and transfer the film to the developing solution. Pass the film back and forth through the developer, as described above for the rinse bath, and continue agitation in this way until the timer rings. Transfer the film to the stop bath, and quickly pass it back and forth several times.

Transfer the roll to the fixing bath and agitate it for about 2 minutes. Then the darkroom lights may be turned on. If the fixing solution is deep enough in the tray, one end of the film can be placed in the tray, and the entire length of the film can be lowered into the tray in folds. However, if the tray is shallow or the roll is very long, it is better to cut the negatives into shorter lengths that fit into the tray. To insure thorough fixing, the film should be agitated several times after it has cleared. When the fixing is complete, transfer the film to the wash. Washing and drying complete the process.

You can well understand that this method of roll-film processing is likely to lead to scratches, uneven development, and tired arms.

Exercises (410):

1. Why is it important to agitate pack film in the presoak?

2. Why is pack film harder to process than cut film?

3. What makes the tray processing of roll film difficult?

2-4. Using Tanks, Hangers, and Reels

Most of your hand processing of film employs tanks, hangers, and reels. These darkroom supplies cut film handling to the minimum, thus reducing the chances of scratches and insuring consistent results. In this section we shall discuss using these tools in film processing.

411. Explain procedures in using tanks and hangers for the processing of sheet film.

Tank development is recommended for processing a number of sheets of film at one time. The tanks filled with the appropriate solutions are deep enough to completely cover the films. The individual sheets are supported by a film hanger. By using the tank method, you will find the solutions last longer and you will be more assured of even processing. Figure 2-3 shows the equipment needed for tank processing cut film.

Loading Sheet Film Hangers. A film hanger is simply a channeled frame suspended below a bar. The bar is long enough to reach across the tank and allows the frame to hang below the surface of the solution. The frame has channels on the bottom and both sides, as well as a hinged channel across its top. Each hanger normally holds one sheet of film. The hangers are manufactured in the normal sheet film sizes such as 4 x 5, 4 x 5 film pack, 5 x 7, and 8 x 10 inches.

The darkroom should be arranged to provide a clean loading area. The hangers should be kept on a special bracket to be easily reached. Space should be provided so that the hangers can be stacked against the wall after they are loaded and before they are placed in the developing tank.

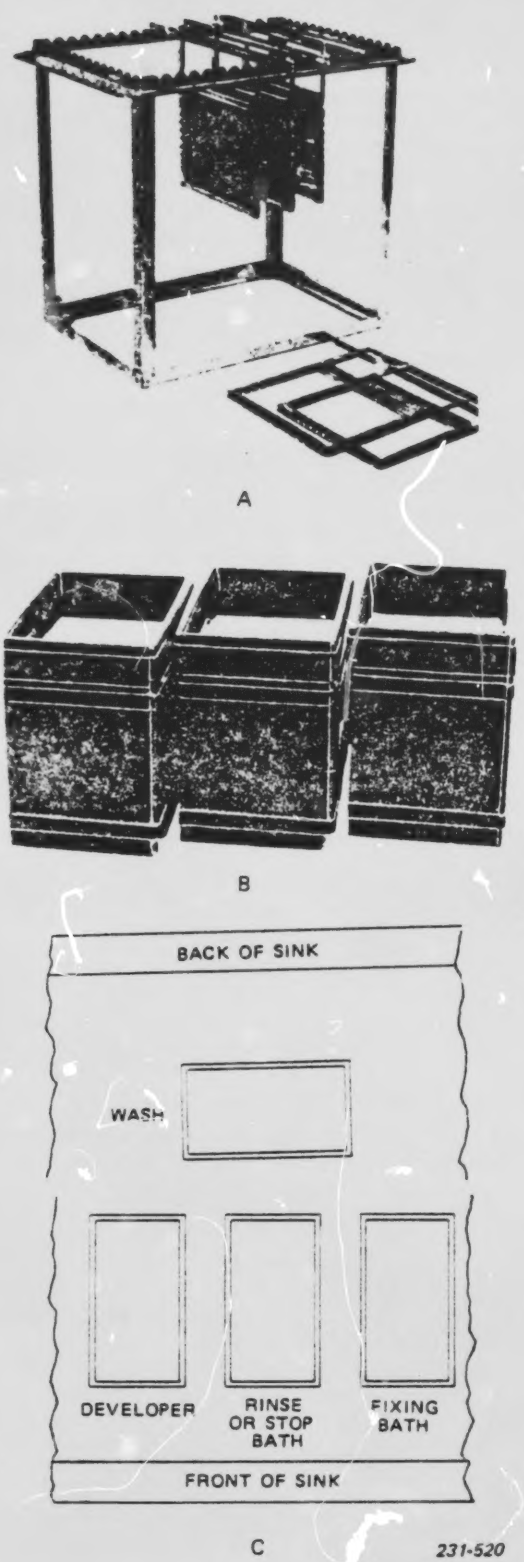


Figure 2-3. Equipment for tank processing cut film.

For loading, spring back the hinged top channel of the hanger so that the side channels are exposed. Hold the hanger in your left hand, and pick up the film with your right. Insert the film into the hanger so that the edges slide into the channels; it may be necessary to tap the back of the film lightly with your fingers to make sure that the film falls into the bottom channel. Spring the hinged top back into place.

You may prefer this other method of loading. First, spring the top channel halfway back. Next, instead of sliding the film into the sides, place most of one edge in the left-hand channel, and curve the film slightly so that the opposite side will spring into the right-hand channel. Only a slight drop is then required for the film to slide into place. Finally, snap the hinged top closed and give the hanger a slight shake to see that the film is free in the channels and has not been pinched or buckled.

Developing Sheet Film. Once the hangers are loaded with film, lift all of them by their crossbars and lower them into the predevelopment water rinse. They should be lowered into the tank until the hanger crossbars rest on top of the tank. The predevelopment water rinse is optional when you are using the tank method of development, but it has all the advantages previously discussed, plus the following, which we have not fully covered before:

a. The air bubbles, which usually occur when dry film is immersed in a solution, can be agitated free without harmful effect.

b. When the water softened emulsion is placed in the developer, the action of the solution begins uniformly over the entire emulsion. Thus, uneven or streaked development is avoided.

c. The predevelopment water rinse removes the antihalation backing dye, which interferes with the action of some developers.

d. The presoak brings the temperature of the film and the hangers to the processing temperature. This is of considerable importance when attempting to maintain constant temperatures in all of the processing solutions.

After 2 minutes, lift the loaded hangers out of the water and allow them to drain. Then immerse all of the hangers into the developer simultaneously with the starting of the timer. This procedure insures uniform agitation and even development. The immersion should be done slowly and smoothly to prevent splashing and the formation of air bells.

Once the hangers are in the tanks, strike them sharply against the sides of the tank several times to dislodge any air bells that may have formed. Leave the hangers undisturbed for 1 minute, and then agitate all of the hangers for 10 seconds, following the pattern illustrated in figure 2-4. Continue the agitation pattern of 10 seconds per minute throughout the remainder of the development time.

At about 10 seconds prior to the completion of the development time, lift the hangers out of the tank and

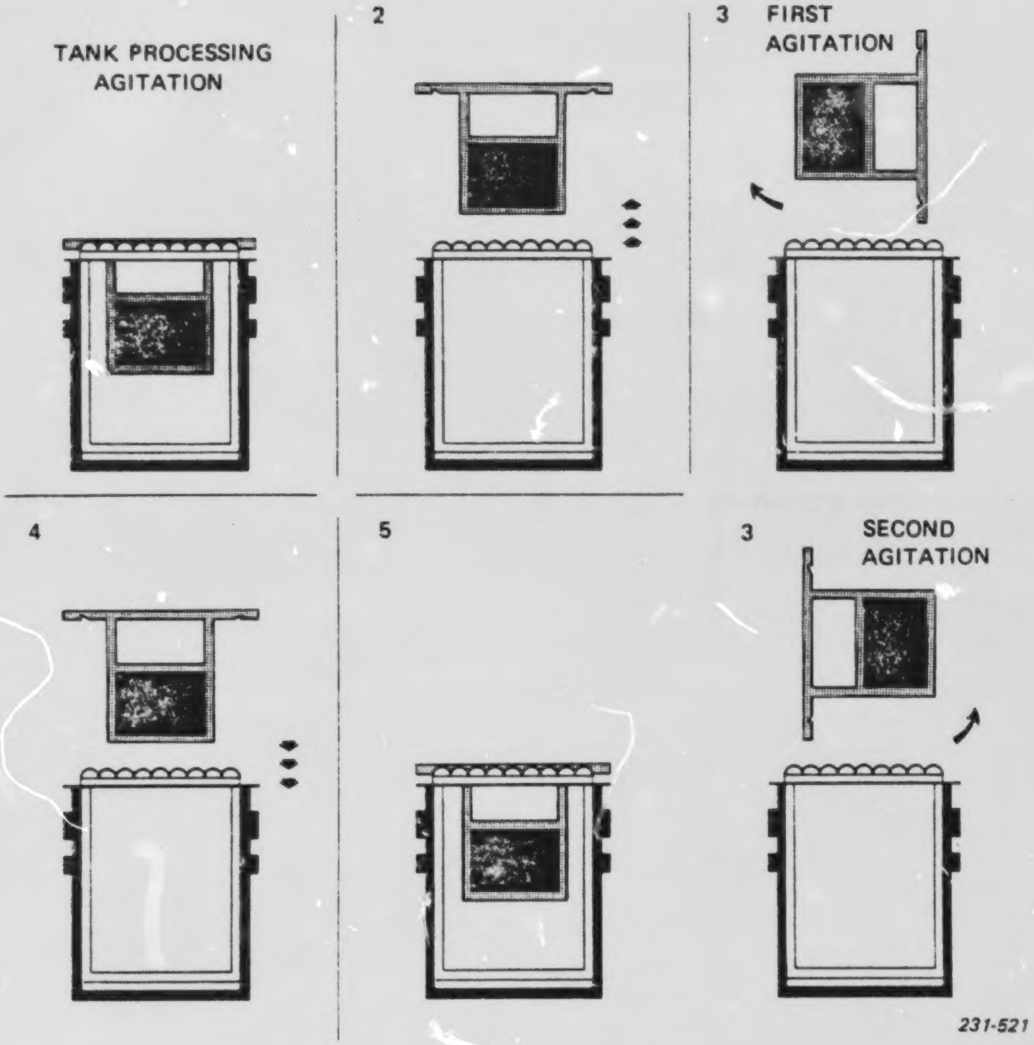


Figure 2-4. Cut-film agitation.

allow them to drain. Then transfer the hangers into the stop bath and agitate them continuously for about 30 seconds. Drain them and then transfer them into the fixing tank. Continuously agitate them in the fixing bath for the first 2 minutes, and then continue agitating on a 10 seconds per minute basis for the remaining fixing time. Drain the sheets again and transfer them to the wash tank. When washing is completed, remove each sheet from its hanger, sponge off the excess water, and hang them up to dry.

If the wet films are dried in the hangers, drying marks from along the edges of the film, thus reducing the actual usable size of the negative image. It is better to suspend each film individually from a line with a film clip, and dry the hangers without film in them.

Developing Film Packs. The procedure for developing film packs by the tank method is performed through using film pack hangers. The film pack hangers crossbar and channeled frame are concave and, unlike with other hangers, the film (with the paper removed) is placed in the hanger with the long dimension vertical. After the loading of the film pack hangers, the processing procedures are the same.

Exercises (411):

1. Why is tank and hanger processing of sheet film better than tray processing?

2. How does a film hanger work?

3. In what manner should the hangers be immersed in the developing tank? Why?

4. Briefly explain the pattern for agitating film.

5. Why should the film be dried off the hangers?

6. What is the main difference between film pack and sheet film tank processing?

412. Explain procedures used in the tank processing of roll film.

Developing Roll Film. It is far more convenient and reliable to develop roll film in a small tank than in a tray. The design, detail, and construction differs somewhat among the various manufacturers' models of tanks, resulting in differences in loading and use. Generally, the basic unit, as illustrated in figure 2-5, consists of a spiraled and grooved reel to hold the film, a tank with a light-tight cover, and a filler cap. Each reel is constructed for a specific size roll of film or can be so converted. The tank top permits pouring the chemicals in and out in the light. Normally, the parts are made out of stainless-steel or plastic.

The proper loading of the film reel in total darkness is one of the most important steps and a challenge to the beginner. First, make sure that both the reel and your hands are clean and dry before loading. Then remove the film from the cassette (35mm or 70mm) or separate it from the paper backing (120 or 220). The film must be handled by its edges in order to prevent scratches. (When working with 35mm, the tongue of the leader must be cut off to make a square end prior to loading.) Next, attach the film to the core of the reel (certain reels load from the outside in), with the emulsion facing the center. Turn the reel while applying a gentle pressure with the thumb and forefinger on the edges of the film. This pressure will produce a slight curl in the film and allow it to pass into the edges of the reel. As you continue to turn the reel, the film will straighten out and fit into the grooved spaces in the reel. Apply enough tension to the film so that it will not skip grooves. However, excessive tension can cause the film to overlap into a reel. (This skill is best practiced in the light a few times with dummy film.)

Once you have the reel or reels loaded properly, you can think about processing. Although all the tanks have provisions for pouring in the solutions after the film is inside, it is best to have the tank already filled with developer. This prior preparation insures more even development. You start the timer, place the loaded reel in the tank, put on the top and cap, and

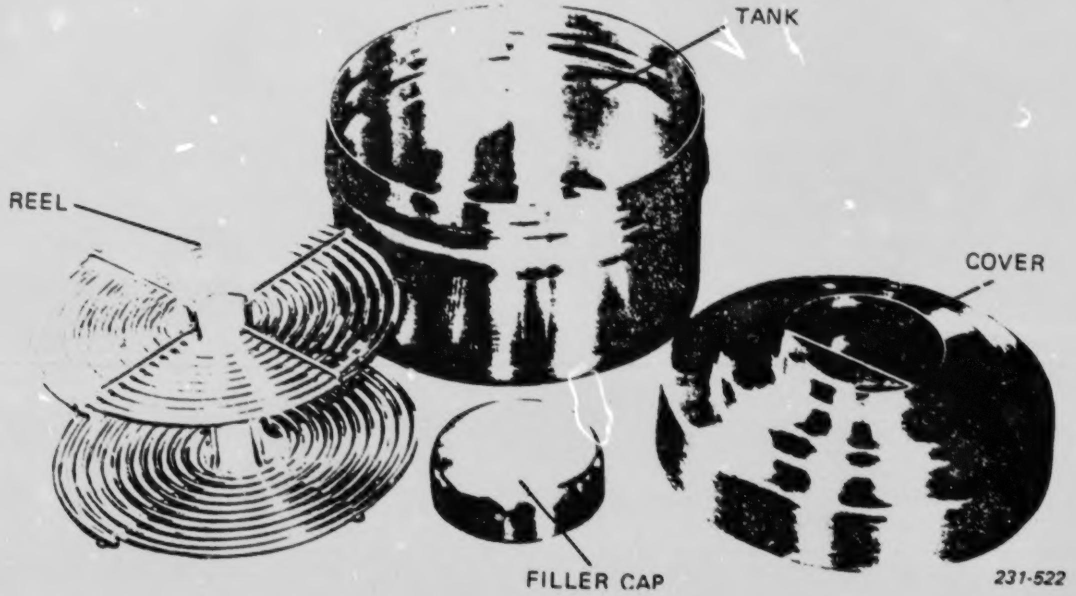


Figure 2-5. Stainless-steel roll-film tank and reel.

then briskly agitate for a few seconds to break any trapped air bells. (Once the top is on, the remaining steps can be done in the light.) You then continue processing for the required time with the correct agitation.

During the last 10 seconds of the developing time, the solution can be poured out from the tank through the light-trapped pouring hole. Fill the tank with water or stop bath solution and agitate for 30 seconds to a minute. Then pour out the solution and pour in the fixer. Agitate the film continuously for 1 to 2 minutes, and then agitate the film at required intervals during the remaining fixing time. Pour out the fixer, and wash the film by removing the tank cover and running a continuous stream of water into the tank for about 20 minutes. Once the washing is completed, sponge off the film and dry it.

(NOTE: To improve your finished product it is a good idea to bathe your film in a water softener such as "Photo-Flo" prior to drying. This technique reduces the chance for water spots. Also, when drying roll film, make sure that you use a clip or clothes pin at the free end to prevent curling.)

Exercises (412):

1. Why is it important to apply just the right amount of tension when you are loading roll film on a reel?

2. Why is it important to fill the tank with developer solution prior to dropping in the reel?

3. How can you help prevent curling when you are drying roll film?

2-5. Time/Temperature Factors

Many factors must be considered if you want to insure correct development during film processing. Two of these are the time of development and the temperature of the developer.

413. State principles related to time and temperature factors in development.

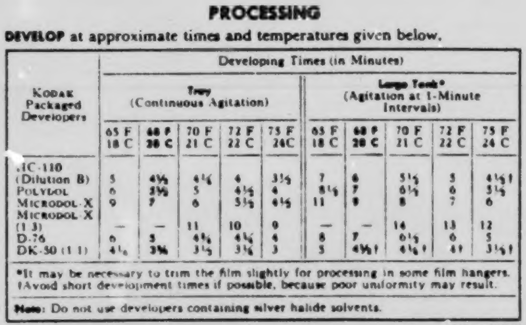
The control of the factors of time and temperature is essential to correct processing. If the film is developed for too short a time or at too low a temperature (or a combination of the two), a weak, low-density negative will result. Such underdevelopment causes a loss of detail in the shadow portion of the negative and reduces contrast. On the other hand, if the negative is developed for too long a period or at too high a temperature (or both), the result is overdevelopment. An overdeveloped negative has useless density, blocked up highlights, and too much contrast. By following a time/temperature chart (illustrated in figure 2-6) supplied with your film or chemicals, you can establish the correct combination that will produce printable negatives. (NOTE: The exact processing time will also be affected by your method of processing. Make sure that the time/temperature chart you use applies to the type of film and processing method you are using.)

Normally, temperature is maintained at 68° F, and the time of development is varied to produce the desired results with the particular film/developer combination. There are several reasons for this standardization. At a temperature of 68° F, the gelatin swells sufficiently to allow adequate penetration of the developing solution without softening to the point where the emulsion is easily damaged (which occurs at higher temperatures). Temperatures lower than 68° F tend to slow development excessively. Only when time is of the utmost importance are high temperatures used. (High temperature processing is a feature of machine, rather than hand, processing.)

When you know the time/temperature relationship for a given film-developer combination, processing in total darkness becomes relatively simple. You adjust solutions to the prescribed temperature and then process for the required time. Assuming proper exposure, time/temperature processing can consistently produce satisfactory results.

Time/temperature processing is a giant step over the old inspection method. The inspection method required checking the negative density under an appropriate safelight. This called for a very experienced eye in order to obtain consistent results. However, this older method is still used when the film is not normally exposed and the person who is developing does not know how much deviation from normal development is necessary to get a satisfactory result.

All solution temperatures (developer, rinse, fixing bath, and wash) should be as near to each other as possible. If there is considerable difference in the



PROCESSING

DEVELOP at approximate times and temperatures given below.

Kodak Packaged Developers	Developing Times (in Minutes)									
	Tray (Continuous Agitation)					Large Tank* (Agitation at 1-Minute Intervals)				
	65 F 18 C	68 F 20 C	70 F 21 C	72 F 22 C	75 F 24C	65 F 18 C	68 F 20 C	70 F 21 C	72 F 22 C	75 F 24 C
HC-110 (Dilution B)	5	4½	4¼	4	3¾	7	6	5½	5	4½†
Polydol	6	5½	5	4½	4	8½	7	6½	6	5½
Microdol-X	9	7	6	5½	4½	11	9	8	7	6
Microdol-X (1:3)	—	—	11	10	9	—	—	14	13	12
D-76	6	5	4½	4¼	4	8	7	6½	6	5
DK-50 (1:1)	4¼	3¾	3½	3¼	3	5	4½†	4¼†	4†	3½†

*It may be necessary to trim the film slightly for processing in some film hangers.
†Avoid short development times if possible, because poor uniformity may result.

Note: Do not use developers containing silver halide solvents.

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Figure 2-6. Sample time/temperature chart.

temperatures between solutions, the emulsion is subjected to excessive expansion and contraction, which may cause it to wrinkle or crack. This effect is called *reticulation*. Normally, this permanent defect renders the negative useless for printing.

Exercises (413):

Complete the following statements related to time/temperature factors in development.

1. During development, negative density increases with both ______ and ______ increases.

2. An overdeveloped negative has ______ density.

3. The normal development temperature is ______ ° F.

4. High processing temperatures can cause excessive ______ of the emulsion.

5. Time/temperature processing is more reliable than the ______ method.

6. If there are wide differences in the temperatures of processing solutions, you may get ______ .

2-6. Agitation

As we discussed different methods of processing, we have indicated the need to agitate the film in each processing step. The technique of agitation is therefore very essential.

414. Discuss the principles and techniques of the hand agitation of film.

Effects of Agitation. The act of moving a photographic film in a processing bath or moving the bath relative to the photographic material during processing is called agitation. The purpose of agitation is to cause a more rapid exchange of the used solution absorbed into the gelatin and the fresh solution from outside the gelatin. One can appreciate the importance of agitation better by studying the effect during development.

During development, the fully exposed areas of the film (highlights) exhaust the developer faster than the middle tones or shadows because there is a higher percentage of exposed halides to be reduced. If there is not adequate agitation, the highlights will not be as fully developed, relative to the middle tones and shadow areas. For the same reason, the middle tones will not be full-bodied. The result is an underdeveloped negative that lacks a good tonal scale, detail, and contrast. Over-agitation causes the opposite problem. Overdevelopment increases contrast and blocks up the highlights. Proper agitation, as recommended by the developer instructions, insures an adequate exchange of fresh for exhausted developer, which results in adequate detail, contrast, and tonal range.

While we have emphasized the importance of agitation in the developer, correct agitation is important in each processing step in order to insure a continuing exchange of fresh for exhausted chemicals over the film surfaces.

Methods of Agitation. Though we have mentioned agitation as we discussed each method of processing, it is a good idea to review the different types of techniques that can be used.

Agitation of sheet film in a tray. If you are processing only a single sheet, one good agitation method is to tilt the tray so that the solution accumulates at one end. Slide the sheet of film emulsion up in at the opposite end of the tray and as you do so, level the tray so that the solution comes in over the sheet of film. Then agitate by rocking the tray, lifting each corner of the tray in a rotational sequence starting with the lower left end and going to the lower right, upper left, and upper right. This rotation insures an adequate cascade effect over the film. Tray agitation is normally continuous except for the latter stages of fixing.

When you are processing a number of sheets of film, the above method will not work. Instead, you transfer each sheet, emulsion side up, into the tray, making a stack. Then you rotate each sheet from the bottom to the top throughout each step. Because this method requires constant handling of the film, care must be exercised in order to prevent scratches. Practice holding the film by its edges to reduce the chance of harm.

Agitation of sheet film in a tank. First, make sure that you are not trying to develop too many sheets at one time. There should be adequate space around each hanger in the tank. Once you are ready to agitate, follow these steps (review fig. 2-4):

(1) Lift the batch of hangers straight up out of the solution. Tilt them almost 90° to the left. Return the hangers to the solution.

(2) Lift the hangers out again, and then tilt them almost 90° to the right. Return the hangers to the solution.

Normally, agitation in tanks is 10 seconds of every minute or 5 seconds of every 30 seconds.

Roll-film tank agitation. Tank agitation of roll film follows the standard tank pattern of 5 seconds every 30 seconds or 10 seconds every minute, the exact method depending on the film/developer combination. The method of agitating the tank depends on its construction. By following the directions, you will get proper results. Normally, a roll-film tank is agitated by inverting it and then returning it to the vertical several times.

Exercises (414):

1. What is the purpose of agitation?

2. A lack of adequate agitation in the developer causes what kind of negative?

3. How can you agitate several sheets of film in a tray?

4. What is the basic difference between tray and tank agitation?

2-7. Solutions

Quality film processing requires the use of the appropriate solution for each step. As we indicated earlier, the chemicals should be properly prepared, at the right temperature, and the film should be processed in the recommended manner. To help you understand the function of the developer, stop bath, and fixing bath, we are going to discuss their chemical makeup.

415. Identify the constituent parts of a developer solution.

Developer. The function of photographic development is to make the latent image in the negative visible by reducing the exposed silver halides to a black metallic silver. There are many chemicals used in a developing solution and each one has a definite function. Developers generally contain (1) a solvent, (2) a reducing agent, (3) an accelerator, (4) a restrainer, and (5) a preservative.

Solvent. Tap water is used as a solvent for mixing the chemical components in a developing solution. Without water, the dry chemicals could neither soften the emulsion nor reach the exposed halides. (NOTE: Distilled water can be used but its additional expense is normally not justified unless the available water is contaminated.)

Reducing agent. The most important chemical in a developing solution is the reducing agent, which actually reduces the exposed silver halides to black metallic silver, making the image visible. There are several chemicals that may be used as *reducing* agents, but only two—hydroquinone and metol—are found in most standard developing solutions.

Hydroquinone is a slow-working, high-contrast reducing agent. It becomes inactive at temperatures over 80° F. Hydroquinone has good keeping qualities, is nonstaining, and produces a cold, blue-black tone.

Metol (also known as Elon, Pictol, and Rhodol) is a soft, but quick-working, low-contrast reducing agent that produces maximum detail. It is affected very little by changes in temperature, has excellent keeping qualities, is nonstaining, and gives a blue-black tone.

Metol and hydroquinone are generally used in combination. The resultant (MQ) developer has the desirable characteristics of both reducing agents and is superior in many ways to a solution containing either agent by itself.

NOTE: There are a significant number of different types of developers. Because of their individual makeups (significantly in the type of reducing agent or agents that are used), they will give you different results. Some will produce high contrast, others will reduce contrast, and still others will permit you to rate your film at a higher exposure index (ASA is used only when you use the official speed rating), giving you a higher effective film speed. By consulting the *Photo Lab Index* and trade literature, you can get acquainted with the different types. Through testing, you can work out the film/developer combinations that give you the results you need.

Accelerator. The developer solution must be in an alkaline state so that the reducing agent will be active. Most agents are either neutral or slightly acid, making it necessary to add an alkali to the developing solution. The alkali, called an accelerator, energizes the reducing agent and also causes the emulsion to soften and swell, thus allowing the reducing agent to penetrate more rapidly.

Accelerators fall into three general classifications: mild, moderate, and strong. Sodium borate (borax) is a mild alkali and is used in low-contrast, fine-grain developers for negatives only. Sodium metaborate is slightly stronger than borax but is similar in action. Sodium carbonate is a moderately strong alkali and is the accelerator used in most developers, for both film and paper. Sodium hydroxide, a very caustic alkali, is extremely active and is used in high-contrast film developers.

The activity of a developer can be changed to a considerable extent by varying the amount of alkali. Because the accelerator is a determining factor in the activity of a developing solution, it has a marked influence upon the degree of graininess produced in a negative. The more active the developer, the greater the clumping action; the milder or less alkaline the developer, the finer the grain.

Restrainer. A developing solution containing only a reducing agent and an accelerator will tend to reduce the unexposed silver halides. Such unrestricted developing action results quickly in chemical fog. To prevent this action, a restrainer, which makes the developer more selective by restraining developing action in the unexposed areas of the emulsion, is added. Because the restrainer also permits longer development, greater contrast can be obtained. An excessive amount of restrainer, however, greatly retards development.

The chemical most commonly used as a restrainer is potassium bromide. Other chemicals that can be used are potassium iodide and sodium chloride (table salt), although they are not entirely satisfactory.

Preservative. A solution containing solvent, reducing agent, accelerator, and restrainer will develop your film. However, such a solution would oxidize very quickly, resulting in rapid deterioration. It would also fog and stain the emulsion. In order to prevent excessive oxidation, a chemical that acts as a preservative is added. The preservative retards the oxidation of the developing agent, making the solution more stable and preventing stains. The chemical most commonly used as a preservative is sodium sulfite.

(NOTE: In addition to the basic ingredients, there may be additional additives that are used for special purposes. For example, sodium sulfate may be added when you are processing at higher than normal temperatures.)

Air Force Developers. The kind of developer you select for processing helps to determine the final result. The Air Force has standardized on the following formulas to fit your requirements:

AF Developer Number	*(Kodak) Formula*	*Description*
1	D-19	High contrast.
2	DK-50	Average grain and normal contrast.
3	D-76	Semifine grain and low contrast.
25	D-72	Suitable for either film or paper.

Exercises (415):

1. Match the developer ingredients listed in column A with the appropriate description of its function listed in column B.

Column A	*Column B*
___ a. Preservative.	(1) Changes exposed silver halides to black metallic silver.
___ b. Reducing agent.	(2) Is necessary to mix the chemicals.
___ c. Accelerator.	(3) Prevents chemical fog.
___ d. Solvent.	(4) Prevents oxidation.
___ e. Restrainer.	(5) Makes the solution alkaline.

2. Match the developer ingredient listed in column A with the appropriate chemical listed in column B.

Column A	*Column B*
___ a. Reducing agent.	(1) Water.
___ b. Accelerator.	(2) Potassium bromide.
___ c. Preservative.	(3) Sodium carbonate.
___ d. Solvent.	(4) Metol.
___ e. Restrainer.	(5) Sodium sulfite.

416. Identify the ingredients, functions, and types of stop baths and fixing baths.

Stop Bath. A stop bath (or rinse) is needed for three functions:

(1) To interrupt development by diluting or neutralizing the alkali of developer that is trapped in the emulsion.

(2) To prolong the life of the fixing bath.

(3) To prevent the fixing bath from staining the photographic emulsion.

There are three general types of stop baths: water, acid, and hardening. Each type has a specific purpose and should be used accordingly.

Plain water helps to retard development and remove excessive developer from the emulsion, thereby minimizing contamination of the fix. Since there is no neutralization of the developer, development will continue to some degree until the film is placed in the fixing bath.

An acid bath stops all development by neutralizing the action of the developer. The neutralization is a result of the chemical reaction between the alkali of the developer and the acid of the stop bath. This type of stop bath insures more accurate development times and definitely prolongs the life of the fixing bath. An acid stop bath is easy to make by mixing the proper proportions of 28-percent acetic acid and water.

A hardening stop bath is used when the emulsion is processed in high temperatures. The hardening ingredient protects the emulsion from becoming excessively soft. A hardening stop bath is made by adding chrome alum to an acid stop bath.

Fixing Bath. When a negative is removed from the stop bath, there are silver halides remaining in the emulsion that were not developed. If these halides are not removed, they will discolor when exposed to light. The function of the fixing bath is to dissolve these silver halides, thereby making the image permanent.

The ingredients found in a fixing bath are as follows:

a. Silver halide solvent—The silver halide solvent is the agent that changes the undeveloped silver halides to a water soluble compound. The compounds are then removed, thereby making the image permanent. The chemical most commonly used as a halide solvent is sodium thiosulfate.

b. Acid or neutralizer—After development, the softened emulsion retains a considerable amount of developer. If this developer is allowed to remain, it will continue its reducing action. Even though an emulsion is thoroughly rinsed in water before it is placed in the fixing bath, enough of the developer will remain to continue developing action. The result will be stains, making the negative unfit to print. To stop development and prevent staining, acetic acid is added to the fix. This acid neutralizes the alkalinity of the developer and stops its action.

c. Preservative—When acid is added to the fixing bath, the sodium thiosulfate decomposes into free sulphur and sulphurous acid. To offset decomposition, a preservative, sodium sulfite, is added. Sodium sulfite acts as a preservative by combining with free sulphur and forming new sodium thiosulfate. It also prevents any discoloration of the solution, which could cause stains.

d. Hardener—During development, the emulsion becomes soft and swollen. If processing is continued without hardening the gelatin, frilling, scratching, and other undesirable effects may occur. The most common hardening agent used is potassium alum. It is added to the fixing bath to allow the film emulsion to harden.

e. Buffer—One last chemical, boric acid, is sometimes added to fixing baths to retard the precipitation of an aluminum sulfite sludge and to prolong the useful life of the fixing bath. Used in this manner, boric acid is called a buffer.

Some common types of fixing baths are the plain fixing bath, the acid fixing bath, and the acid hardening fixing bath.

A plain fixing bath contains nothing more than sodium thiosulfate (hypo) and water. It is very seldom used except for special purposes, such as fixing prints that are to be toned.

An acid fixing bath is a solution of sodium thiosulfate combined with the proper proportions of acetic acid and sodium sulfite. This type of bath is unsatisfactory for negatives because it has no hardening qualities. It is primarily intended for black-and-white prints.

The acid hardening fixing bath is an acid bath containing a hardening agent to protect the emulsion. It is the most popular type for film.

Exercises (416):

1. List the three purposes of a stop bath.

2. What two ingredients are used to make an acid stop bath?

3. What are the three types of stop baths?

4. What is the primary purpose of the fixing bath?

5. What are the three types of fixing baths?

6. What ingredients go into an acid hardening fixing bath?

2-8. Processing Black-and-White Positives

The purpose of making a black-and-white positive (transparency) is to obtain an image that is viewed by transmitted light instead of reflected light like a print. The steps necessary for processing black-and-white positives are identical to that used for negatives. The only difference is the type of film/developer combination that is used to obtain the image.

417. Briefly explain how to produce a black-and-white positive.

Black-and-white slides can be made by printing on film. Fine-grain positive films, like Kodak's Commercial Film 6127 or High Contrast Copy, are the best emulsions. Your black-and-white original negative is then contact printed onto the copy film. (We shall discuss contact printing in greater detail later in this volume. For the time being, we'll state that contact printing requires only that the negative and the film be held together emulsion to emulsion and that the film be exposed by passing light through the base of the negative. A contact printer, which is used to do this, is essentially a box that contains a lamp, a piece of glass upon which to put the materials, and a lid to hold them flat together.) The film is then developed according to directions, like the following:

Film	*Development*
High Contrast Copy	D-72 diluted 1:1, 6 minutes at 68° F (Ta[illegible] intermittant agita[illegible]
Kodak 6127	DK-50, 2 m[illegible] at 68° F (Tray—constant agitation).

After processing, the film is fixed, washed, and dried. After drying, the film is cut and then mounted. Glass mounts should be used so that the film will not buckle under the heat of the projector.

Exercises (417):

1. Briefly outline how a black-and-white positive can be made from an original negative.

2. Why should glass mounts be used for slides?

Film Finishing

EVERY STEP IN the photographic process is important. In the previous chapter we emphasized the developing and the fixing of the film. Film finishing is vital too. In this chapter, we shall discuss washing, drying, spotting and opaquing, archival quality, and handling and storage.

3-1. Washing Film

Properly washing your film is as important as the processing steps that precede it. It is therefore worth your while to learn proper washing methods.

418. Complete statements regarding the principles and techniques associated with proper film washing.

An unwashed or improperly washed emulsion will stain, crystallize, and fade. It is therefore essential to remove the complex salts formed by the fixing bath as much as possible. The salts that remain in the emulsion will discolor with time.

Factors That Affect Washing. The amount of time that film has to be washed is dependent upon the following factors:

a. Efficiency of the washing system—The more rapidly fresh water comes in contact with the film, the less washing time that is required. Washing systems therefore should have a constant flow of water and a drainage system that is removing the contaminated water.

b. Chemical composition of the fixing bath—Film processed in nonhardening or chrome alum fixing solutions wash faster than materials processed in fixing baths containing potassium alum. When film is fixed in a potassium alum fixing bath, washing time varies with the pH of the bath, being more rapid at pH values above 4.9. (pH is explained in detail in the fourth volume of this course. Briefly, pH rates the alkalinity, acidity, or neutrality of a solution on a scale that runs from 0 through 6.9 (acid), 7 (neutral) and 7.1 to 14 (alkaline). 4.9 indicates a moderately acid solution). Washing is faster when the material has been fixed in a fresh fixing bath than when it is fixed in a partially exhausted bath.

c. Temperature of the wash water—Properly hardened films wash more rapidly in warm (75° F) water than in cold (65° F) water. Extremely high temperatures will damage the emulsion, and you don't want to deviate far from the temperatures of your processing solutions or you may get reticulation. If you processed the film at 68° F, washing at 75° F is not likely to cause a problem and is an effective washing temperature.

d. pH of the wash water—Increasing the pH of the wash water from 7 (neutral) to 11 (by the controlled addition of ammonia) reduces the washing time. This practice however, is rarely carried out.

e. Amount of hypo in the emulsion—The amount of hypo that is being retained by the film may vary with its construction and the type of fixing solution that is used. For example, positive emulsions are thinner than negative emulsions and therefore retain less hypo and can be washed in less time.

f. Degree of hypo removal required—Standards vary on the amount of hypo that must be removed for a satisfactory result. Normally, 0.02 to 0.4 milligrams of hypo per square inch is permissible for ordinary work. True archival quality (lasting permanence over a number of years) requires that residual hypo be limited to 0.005 milligrams per square inch. On a practical level, a negative that is going to be used only for a couple of prints and then is going to be thrown out can receive less washing than one that is going to be sent to a film repository.

Washing Methods. Let us review a couple of methods for washing sheet or roll film.

There are two basic methods of washing sheet film. One method is to place the negatives in a tray of water and then change the water about every 3 minutes for a minimum of 10 changes. A more efficient tray method of washing is accomplished by attaching a device to the edge of the tray that siphons the water from the bottom of the tray while the fresh water runs in at the top. The second and a very satisfactory method of washing negatives is in a tank. Film hangers hold the individual negatives suspended separately in a tank while water is pumped into the tank. With either method, you must make sure that the negatives are separated so that a sufficient amount of fresh water reaches all areas of each negative. Keep in mind that the tray method can usually handle only a few sheets of film at a time.

Roll film may be washed by removing the tank cover and running a stream of water into the tank. You should insure that the tank is emptied every few minutes so that chemicals are not collecting at the bottom. A very efficient method is placing the reel into a specifically designed roll-film washer, which consists of a tube in which the reel is placed and through which water is forced in at the bottom.

Regardless of the method you use, plan to wash your film at least 20 minutes unless otherwise directed.

Exercises (418):

Complete the following statements on film washing.

1. A __________ exchange of __________ water is essential to efficient washing.
2. Film fixed in a fresh fixing bath requires __________ washing time.
3. The __________ the temperature of the wash water, the __________ the washing time.
4. Archival quality requires that the residual hypo be limited to __________ milligrams per square inch.
5. The __________ method is suitable for washing a few sheets of film.
6. Roll film can be washed in the __________ in which it is processed.

3-2. Use of Wetting Solutions

The proper use of a wetting solution insures that your negatives will dry properly. Let us see how they work.

419. Briefly explain the purpose and use of wetting solutions.

Purpose of Wetting Agents. After washing, water often drains from film in an irregular manner, clinging to both the emulsion and base sides in drops, streaks, and uneven patterns. If such partially drained or incompletely wiped films are subjected to vigorous drying conditions like hot air blasts or intense radiant heat, the areas under these streaks and drops of water dry much more slowly than the surrounding film. The swollen gelatin at these points is thereby subjected to stresses and shrinks unevenly, changing the density of the silver image. Even when surplus water is removed from the emulsion side, if drops of water remain on the base side, drying of the emulsion immediately opposite the water spots is retarded and drying marks may result.

Wetting agents are chemicals that lower the surface tension of liquids, thereby breaking down droplets of water. The film will thereby dry faster and more evenly. The common commercial wetting agents that are designed for photographic use include Kodak Photo-Flow, Edwal Kwik-wet, and Pako Pakowett.

Proper Use of Wetting Agents. A typical method is to bathe the film after washing for about 2 minutes in a 2-percent solution of the wetting agent. The exact concentration depends on the product being used. (About a quarter of a cap full of Photo-Flow in an 8 x 10 tray of water is sufficient.) Do not use too much wetting agent, as this can cause stains or a scum to form. Once the film has been bathed, drain it and sponge off the excess liquid.

Exercises (419):

1. Why should film be bathed in a wetting solution prior to drying?

2. Explain how to use a wetting solution.

3-3. Drying Film

Once negatives have been fixed and thoroughly washed, they are ready for drying. In the drying process, as with all other stages of development, proper handling of the film is essential.

420. State principles and procedures related to the drying of a film.

Basic Principles. In order for a negative to dry, it must be surrounded by dry air (i.e., air that contains a lower relative percentage of moisture than the gelatin). Warm air accepts more moisture than cold. However, if the air is not circulating, even heated air can rapidly establish a state of equilibrium with the moist film, and drying will stop. Causing the damp air to move away from the surface of the wet film and replacing it with dry air will permit drying to continue. This is the principle behind the air impingement dryers currently in use.

Photographic films and plates begin drying at the corners and edges as well as in the areas of heaviest density. Strains in the direction of the dry areas take place. While a glass base resists these strains, cellulose acetate, being flexible, will curl in the direction of the dry areas. As the film continues to dry, the strains gradually begin to equalize; and the film, if properly dried, ultimately lies flat. (NOTE: Film should never be dried to the point that it becomes brittle. Brittleness can be a recurring problem in a low-humidity environment.)

Drying Methods. Drying by natural evaporation is quite good and negatives can dry in much less than 30 minutes where you have adequate air circulation. Where speed is critical or where there is high humidity, drying can be accelerated by hot forced air. However, this method may cause damage to the emulsion. Forced drying attracts the lazy technician who wants to "get on with it," but it is seldom really necessary.

The air impingement system is commonly used in the Air Force. In this system, air is warmed and blown against (impinges upon) the surface of the wet film. The warm, dry air picks up moisture and moves on. It is immediately replaced by more warm, dry air and the process continues until the film is dry. The rate of drying is controlled by adjusting the velocity, temperature, and humidity of the air in the drying chamber. In very hot and humid climates where the air is saturated with moisture, the air must be passed through a dehumidifier before it enters the drying chamber. If this is not done, the film will not dry. In very dry climates, it is necessary to reduce both the heat and the air velocity to prevent overdrying.

It is important to keep in mind that warm air is used, not hot air. Use a very moderate temperature setting on your film dryer. In fact, try drying film without using any heat; you may be pleasantly surprised what just good circulation of air will do.

Drying Problems. The primary problems to guard against are uneven drying, dust, scratches, and damage to the emulsion caused by overheating. After washing, both surfaces of the film should be gently cleared of excess surface water with a clean, soft chamois or a viscose sponge. The film should be dried in a vertical position, hanging from a line or beam by film clips. With roll film, you can prevent curling by attaching another film clip to the bottom of the film. Film should *not* be left to dry in a hanger or a reel; if it is, uneven drying and drying marks will result.

Dust and water spots are the most frequently encountered problems in drying films. Dust, if not imbedded in the emulsion, may be removed with a camel's hair brush. Imbedded dust requires that the negative be rewashed and properly dried. Water spots, which are small crater-like formations in the emulsion, can cause permanent damage. (The damage is the uneven density caused by the water spot. The spot therefore shows in the print.) The best cure is prevention. These problems can be avoided by using a hardening fixing bath, by keeping the film surface clean and clear, and by using a wetting agent rinse.

Exercises (420):

1. What type of air do you need to dry film?

2. Strains caused by drying go in which direction?

3. Film will become brittle in what type of environment?

4. Rate of drying is controlled by what three factors?

5. In drying films, what may result if you use air that is too hot?

6. How can you prevent roll film from curling?

7. Why are water spots a serious problem?

421. Complete statements regarding the operation of film dryers.

Film Dryers. The Air Force maintains a number of different types of film dryers in its inventory. Each dryer has its own procedures for operation. You should, therefore, consult the appropriate technical order or manufacturer's booklet to insure effective drying. For purposes of discussion, we shall outline the instructions for operating the EL-4 dryer, which is illustrated in figure 3-1. It is a typical dryer and is used in many base laboratories.

Prior to drying, follow the proper film processing procedures, as recommended by the film manufacturer, which will insure top-quality drying results. Drain the films for a short period before placing them in the drying cabinet.

A control panel, located on the right side panel of the cabinet, contains the main switch, thermostat control knob, pilot light, and nameplate. (See fig. 3-2.) Operate the dryer as follows:

(1) Turn main switch ON.

(2) Set the thermostat control knob at 100° F. After a warmup period, with an outside temperature of 65° to 75° F, the thermostatic control regulates the temperature in the cabinet to within plus or minus 10° F of the actual temperature setting in any portion of the drying space. The pilot light indicates proper function of the heating element. (NOTE: The heater assembly is wired for safety and will not operate until the blower has been turned on.)

(3) The heated air currents should strike the edge of the film and blow across the film surface. Avoid excessive heat, which tends to curl film.

(4) To stop the dryer, first turn the thermostat to OFF and then turn off the main switch. The indicator light on the control panel will not burn when the dryer is completely shut off.

The dryer should be properly maintained and kept spotlessly clean in order to insure good results.

Exercises (421):

Complete the following statements related to film dryer operation.

1. It is essential that the dryer be kept ________ to insure dust-free negatives.

2. The thermostat of the EL-4 dryer should be set at ____ ° F.

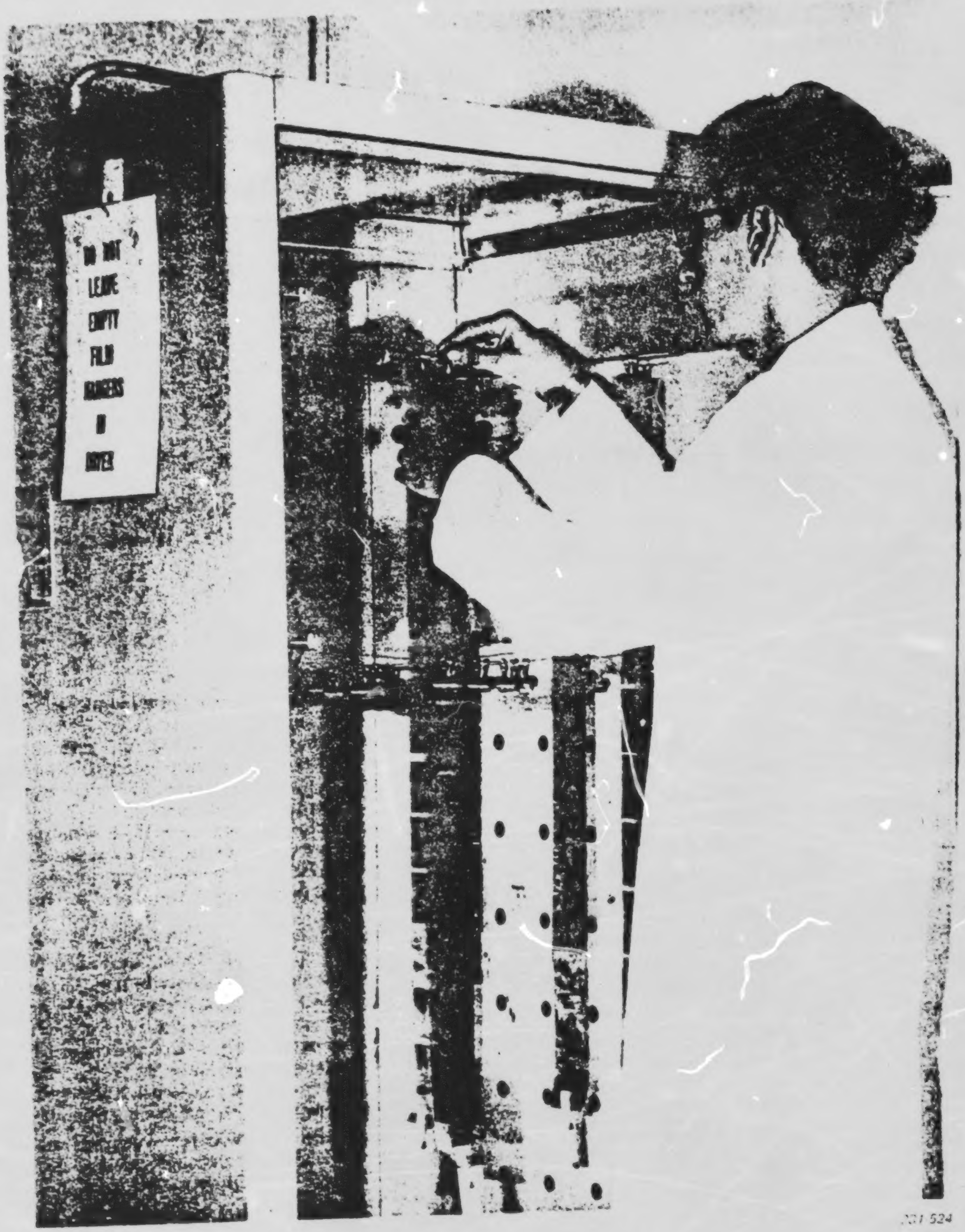

Figure 3-1. Typical film dryer.

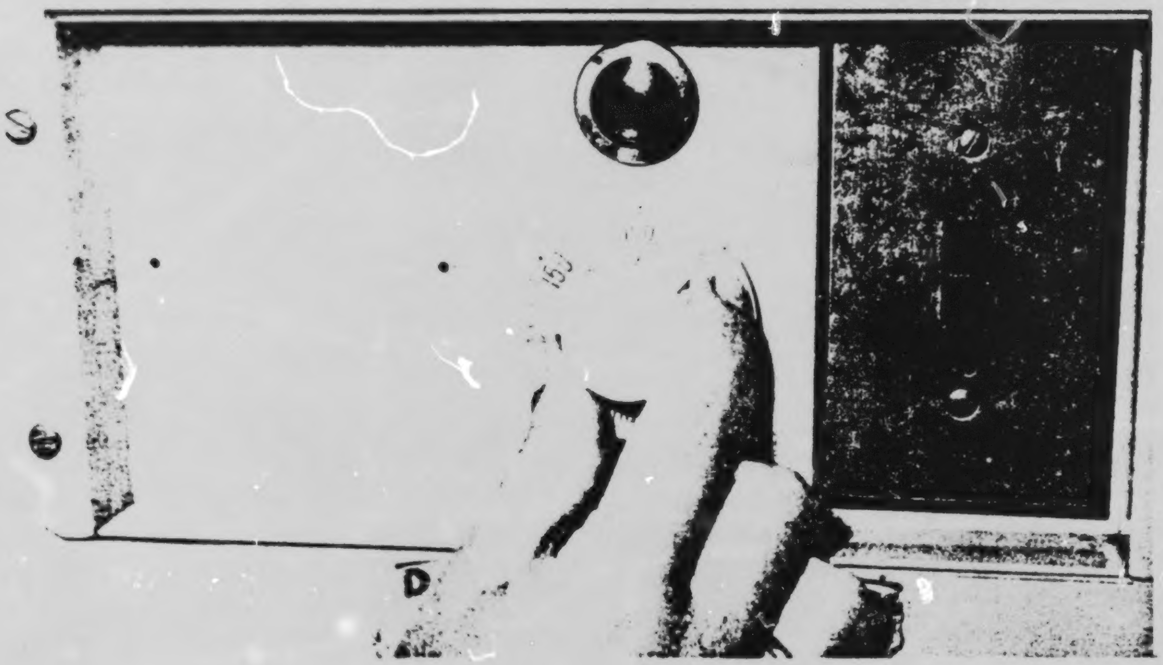

Figure 3-2. Film dryer temperature control and power on/off switch.

3. Film should be ________ prior to placing it in the dryer.

3-4. Etching, Spotting, and Opaquing Negatives

Handwork is performed on negatives to correct defects and to make improvements in the final print. It is important that you acquire a practical working knowledge of the techniques and processes involved so that you may produce the best possible prints from your negatives. Etching, spotting, and opaquing are some of these basic handwork techniques.

422. State the purpose and identify basic techniques associated with etching negatives.

Etching is aimed at one goal—the removal of part of the emulsion that forms a portion of the image. This removal of black metallic silver is strictly a mechanical process of shaving off tiny layers of the emulsion until the correct density is achieved. The principal tool used in this process is the etching knife.

The effect of etching is to reduce density in the area that is etched. This technique is often used in reducing negative defects and facial defects like blemishes, freckles, and skin spots in portrait negatives. Etching is applied only to large roll and sheet film negatives. A 2¼-inch square negative would be the minimum size to work on.

Due to the skill required, you should carefully examine a print made from the negative and make sure that it would not be faster and more satisfactory to spot the print. (Print spotting will be discussed later in this volume.) If only a few prints are to be made from the negative, etching is a waste of time. However, when a large number of prints are to be made, you can often save time by making a single correction on the negative.

Etching Knives. The etching knife should be set aside and used for nothing but etching. Regardless of its shape or size, the etching knife must be honed to an edge that approaches perfection. Unless the etching knife has the best possible cutting edge, you will never be able to do a satisfactory job of etching. Very often, miscellaneous etching knives are made by the photographer himself. All that you need to make one is a needle of the appropriate size and a wooden handle. After mounting the needle in the handle, you grind and hone the end of the needle to the appropriate shape. Small pieces of razor blade properly mounted in a handle also work well.

Etching Procedures. To prepare a retouching easel, secure to a small easel a sheet of 1/8- or 1/4-inch plywood that has a center hole measuring 2 inches in diameter. Behind this hole, secure a sheet of diffusing glass. At the base of the easel, you can put a light source. (There are, of course, professional retouching easels that are manufactured.)

The plywood work surface serves a dual purpose. First, it limits the illumination to a small area being worked and thus prevents excessive glare in the eyes. Second, it holds the negative a short distance from the diffusing glass of the easel so that any blemish on the glass is not mistaken for a defect in the negative.

Set up the easel so that the best possible illumination is given the negative. Regardless of the type of easel you use, you can vary conditions until the illumination is sufficient. If excessive sidelights prove detrimental when you are working, cut triangular sheets of black paper to fit the sides of the easel and tape them in place. Be sure to position the easel in such a way that a minimum amount of light comes from behind you.

Pin the negative over the aperture by one corner only. In this way, it can readily be moved from one position to another with a minimum amount of effort. Test the etching knife on the corner of the negative to be certain that it will shave smoothly without scratching. Hold the knife blade in such a position that the cutting edge is approximately perpendicular to the surface of the negative. Film is ordinarily not very rigid, so it is best to etch small areas at a time. As the knife is moved back and forth across the area, the cutting should occur in one direction only, preferably right to left. Use a stroke not longer than 1/8 inch in length. Each stroke should be separate. Do not develop the undesirable habit of trying to remove emulsion on both movements of the knife. The quality of work will not be satisfactory.

Begin by etching very lightly. When the blade begins to drag on the emulsion, increase the pressure slightly. You can do a much better job of etching with many light strokes than with a few heavy ones.

Many times, in actual practice, more emulsion is removed than was planned. This leaves the etched area with too little density. Overetching can be corrected by retouching the area to the correct density. For this reason, etching is done before the negative is spotted.

Exercises (422):

1. What is the purpose of etching?

2. Complete the following statements on etching.

   a. Etching is accomplished on ______-size negatives.

   b. The basic tool in etching is the __________.

   c. A specially designed ______ is used to hold and illuminate the negative.

   d. Cutting should be done in only ______ direction.

   e. It is best to use ______ strokes when you etch.

   f. Overetching can be corrected by ______.

423. State the purpose and indicate basic techniques of spotting and opaquing negatives.

Spotting and opaquing are more common types of negative handwork than etching. You should be able to apply both these techniques.

Spotting. The term "spotting," applied to negatives, refers to the practice of eliminating pinholes or small transparent areas in the emulsion. When a pinhole is not corrected, it appears as a black spot in the print. If the cut is only in the emulsion, it appears as a diffused white spot. By spotting, these defects appear as clear white spots on the print. These white spots can then be easily eliminated when you spot the print.

Spotting Technique. Place the negative on the retouching easel, contact printer, or plotting table, with the emulsion side of the negative toward the glass. Dip a mapping pen in the spotting dye. Using good magnification, lightly touch the spot on the back (base) side of the negative. With care, you can confine the dye to the spot without spreading over the surrounding area. Use extreme care in keeping the point clean if fine work is to be done quickly. You will notice that the penpoint has a tendency to pick up small pieces of gelatin from the negative.

Because pinholes are actually small holes in the film, they cannot be spotted on the emulsion side of the negative. The capillary action draws the dye to the sides of the hole, and the pinhole remains uncovered. At best, a pinhole is very difficult to correct on a negative; sometimes it can be successfully done on the base side of the negative with dye.

Opaquing. Opaquing is covering an undesired portion of the negative with a light-resistant dye or opaque. When such a procedure is used, the block portion of the print appears white. This technique is therefore routinely applied to high-contrast copy negatives that have numerous pinholes.

Opaquing Technique. Begin by placing the negative on a well-illuminated surface, such as a printer, retouching easel, or plotting table. The negative may be blocked on either side or both sides if necessary. It is best, however, to block on the back (base) side of the negative; this avoids possible scratching of the emulsion.

Saturate a cotton swab to about half its length with 1A red dye. Follow the outline of the image, using short, side-to-side strokes. Work slowly, allowing sufficient time for the gelatin to become saturated with the dye. Experience and practice make it comparatively easy to follow the outline accurately. Use the swab the same way you would use a pencil or crayon. It may be necessary to block on both sides of the negative if the area to be blocked is very thin and the remaining image quite dense. This, however, would be an exceptional case. Narrow areas may be filled in with a mapping pen. One common practice is to outline the subject with a mapping pen and block the remainder of the negative with a brush. Normally, however, you will not completely reverse a background from black to white.

Dye blocking does not crack or flake off from the negative. Once it is applied, it becomes permanent. Errors made may be removed by lightly wiping the area with a cotton swab and clean water. If the dye is not completely removed with water, use a 10-percent solution of sodium sulfite. All of the dye may be removed by soaking the negative in a tray of such a solution. With moderate agitation the red color and the resulting yellow stain both disappear. Wash the negative in running water for 5 minutes and then dry. You may then repeat the blocking process if you desire.

Opaque may also be used for the blocking process. Although it may have a tendency to crack and flake, it does have the advantage of completely blocking with a single application. Furthermore, it may be used in a rather thick consistency and thus does not tend to run as the red dye does. It is exceptionally good for following along the edges of objects.

Exercises (423):

1. What is the purpose of negative spotting?

2. What is the purpose of opaquing?

3. Complete the following statements on spotting and opaquing.

   a. A pinhole that is spotted on a negative will appear ______ on a print.

   b. Normally, spotting is done on the ______ side of the negative.

   c. A pinhole is a ______ ______ in the film.

   d. ______, unlike red dye, can block with a single application.

   e. When water is not sufficient, a 10% solution of ______ ______ can be used to remove the dye from a negative.

3-5. Achieving Archival Quality

Archival quality in photography means the keeping qualities of the final product. If photographic material has been processed for archival quality, the material will not deteriorate with the passing years.

424. Explain techniques applicable to achieving archival quality.

Anything that may lead to or prevent eventual deterioration of the photographic image must be given your careful consideration. Only in this way can you produce materials having the best keeping quality obtainable. You must take into consideration such factors as the composition of the stop bath, fixing bath, and wash. In addition, you must consider such aids as hypo eliminators.

Stop Bath. The pH of the stop bath has an effect on the archival quality of the film you are processing. For best results, the acetic acid stop bath should be maintained between a pH of 4 and 6—low enough to react with the alkali of the developer and yet high enough not to cause any damage to the emulsion. The acid used in the stop bath should be weak so that its reaction with the alkali will be slow. Very strong acids diluted to the proper pH do not have the best archival effects. Since acetic acid meets the desirable requirements, it is normally used in stop baths when you are striving for permanence.

Fixing Bath. The freshness of a fixing bath is a vital factor in the keeping qualities of the final product. As a fixing bath approaches exhaustion, the salts that form are increasingly difficult to dissolve from the emulsion. When the archival quality of specific pieces of material is of utmost importance, frequent controlled checks of the fixing bath are essential. These checks are especially important if the processing is done with equipment that uses fixing bath recirculation, silver recovery, and fixing bath replenishment.

A double fixing bath arrangement is considered desirable for the attainment of archival quality. A fresh fixing bath is placed in the first bath and a partially used fixing bath may be placed in the second bath. When the second bath approaches exhaustion, it is discarded. The used first bath is placed in the second position and a fresh fixing bath is placed in the first position. By fixing the film for about 5 minutes in each bath, you can be fairly well assured of adequate fixation.

Hypo Clearing Agents. Many treatments have been prepared for shortening the washing times or converting the hypo to a harmless material. Three types of hypo eliminators are especially effective. They are alkalies, alkaline solutions of oxidizing agents such as hydrogen peroxide-ammonia, and neutral salt solutions.

Washing. Films and plates can be adequately washed by water alone, provided there is adequate renewal of the wash water and sufficient time given. If an ammonia bath is used, however, the process may be speeded up. After washing for 10 minutes in water, the films or plates should be bathed in a 0.3 percent solution of ammonia (10 cubic centimeters of 28-percent ammonia per liter) for 3 minutes and then, washed for 2 or 3 minutes. The rate of washing is also increased if a nonhardening or a chrome-alum fixing bath is used.

While the purity of water used to wash photographic materials may not be as critical as the purity of the water used in mixing the chemicals, it is nonetheless an important factor. When the water comes from the same supply as that used for human consumption, the water is normally pure enough for washing photographic materials.

It is important that the wash water used for film be reasonably free of chemicals or contaminants. If large amounts of sensitized materials are being processed, you should run a periodic check on the photographic chemical content of the wash water to make sure that it is not contaminated.

Available wash water may be contaminated with vegetable or animal matter; dissolved salts such as bicarbonates, chlorides, and sulfates of calcium, magnesium, sodium, and potassium; or grit or other foreign substances. Almost any water can be purified to meet photographic washing requirements, but the method of purification depends on the type and amount of contaminants.

Your main reason for analyzing the wash water is to insure image permanence. It is impossible to wash the fixing bath and byproducts of fixation from the emulsion of sensitized materials if the wash water is loaded with these very chemicals.

One method of checking the wash water is to measure the pH of clean unused water (from the same source as the wash water), check the pH of the wash water in contact with the materials as it leaves the wash tank, and then make a comparison of the two pH readings. If the readings compare favorably, you can be reasonably sure that the washing is effective.

Exercises (424):

Complete the following statements on the techniques used to achieve archival quality.

1. For best results you should use an ______ ______ stop bath that has a pH between ______ and ______.

2. A ______ fixing bath arrangement can better insure archival quality.

3. As a fixing bath approaches exhaustion, the ______ that form are difficult to dissolve.

4. Wash time may be reduced by using an ______ bath.

5. It is important to have reasonably ______ wash water.

3-6. Handling and Storing Negative Material

Can you afford to have your precious negatives lie around after your efforts in shooting, processing, and finishing? Proper handling and storage of your negatives is just as important as carefully loading your camera to begin the photographic process.

425. Indicate principles and techniques applicable to the handling and storage of negative material.

Storage Problems. Moisture, strong light, and heat can damage any film. Processed films should therefore be stored on the main floors of buildings, never in basements, which may be damp, nor in attics, which may be hot. A relative humidity of 25 to 50 percent and a temperature of 70° F or less are best. It must be emphasized that high relative humidities are more dangerous than high temperatures, because of the possibility of fungus growth. In localities where inside relative humidities of 60 percent or higher prevail, it may be advisable to build a moisture-proof box in which to store a film collection with silica gel. The box should be provided with a rubber gasket to make a tight-closing lid, and the films should be arranged to permit adequate circulation of air within the box.

To prevent physical damage, film should never be touched with the fingers except at the edges. Sheet and roll-film originals should be kept in the transparent sleeves designed for storage purposes. If much handling is required, it might be wise to make duplicate negatives and keep the original master on file.

Archival Storage. Valuable documentary film records that are to be preserved indefinitely should be stored in carefully controlled conditions rather than makeshift arrangements. The storage vault or record room should be carefully constructed. Proper insulation and air conditioning facilities should maintain the relative humidity between 40 to 50 percent and the temperature between 60° to 80° F. Low temperature favors preservation, but if the storage space is below the dew point of the outside air, the records must be allowed to warm up in a closed container before they are used or a condensation of moisture will result.

The air should be filtered to remove dust, cleaned of reactive gases where necessary, and circulated under slight positive pressure. Sufficient fresh air should be supplied to provide for personnel working in the room. Atmospheric contaminants, such as paint fumes, hydrogen sulfide, sulfur dioxide, and similar gases, may cause slow deterioration of film base and gradual fading of the photographic image. The removal of such gases from the air requires special consideration.

Films should be stored in metal cabinets with adjustable shelves or drawers, depending on the filing requirements. The walls of the cabinets should have louvers or openings located to facilitiate the circulation of conditioned air through the cabinets. The cabinets should be spaced in the room so as to permit the free circulation of air around them.

The records should be protected from water damage, whether from leaks, fire sprinkler discharge, or flooding. Drains should be provided; these should have sufficient capacity to keep the water from sprinkler discharge from reaching a depth of 3 inches. The storage cuabinets should be raised so that the lowest shelf or drawer is at least 6 inches off the floor, and they should be constructed so that water cannot splash through the ventilating louvers onto the records.

Checks of various films being stored should be made at regular intervals to insure that the precautions being taken are sufficient. Remember that every effort should be made to take care of the film, for the subjects in almost all cases cannot be photographed again.

Exercises (425):

1. What are three conditions that are likely to cause damage to film?

2. For archival quality, film should be stored at what relative humidity levels?

3. High relative humidity can cause what kind of film problem?

4. Why should storage cabinets be raised off the ground?

5. Why should the air entering the storage area be filtered and cleaned?

6. What should be done if there must be extensive handling of a particular sheet of film?

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Black-and-White Sensitized Print Material

BLACK-AND-WHITE prints make up the majority of general purpose photographs used in the Air Force. As shown in figure 4-1, the structure of print paper is simliar to that of film. The main differences are the paper base and the baryta and gelatin coating. The paper base is made from a very pure sulfite pulp stock and comes in three weights: light, single, and double weight. The baryta and gelatin coating acts as a filler to support the emulsion and aids in the reflecting ability of the paper. Just as you should have a thorough understanding of the films you use, you should be well aware of the different types of paper you will be printing on.

There are basically two broad categories of black-and-white printing papers: graded and variable contrast. These two types are based on how image contrast is controlled. We shall first discuss graded papers and then move on to the variable-contrast type.

4-1. Graded Papers

In this section we shall discuss various characteristics of graded papers, including their sensitivity to light and contrast ranges.

426. Identify different types of graded papers in regard to their sensitivity to light.

Sensitivity of Graded Papers. Just as there are different film speeds, papers vary in their sensitivity to light. You should understand these differences, as they may have a bearing in your paper selection and printing method. Sensitivity can be an especially vital element in production printing when hundreds of prints have to be turned out in a short time.

Just as with films, the type and color sensitivity of the silver halides used in the emulsion determines the light sensitivity of the paper you are using. The following is a breakdown of the various types of graded papers in terms of their sensitivity.

Silver chloride papers. Chloride papers have only silver chloride halides in the emulsion. This type of graded paper is sensitive to the untraviolet, violet, and the blue portion of the electromagnetic spectrum. The sensitivity decreases sharply beginning with the center of the blue spectrum. Chloride papers are therefore comparatively slow, making them suitable for contact printing. Their low sensitivity permits handling under bright yellow (Wratten 00) safelights.

NOTE: There are two basic printing techniques: contact and projection. In contact printing the negative and paper are held together during exposure. This method produces a 1-to-1 image. In projection printing the negative is separated from the paper and the image is projected by an optical system. Projection printing permits different size images to be produced. Both methods are discussed in Chapter 5 of this volume.

Silver Bromide papers. This type of paper emulsion usually contains only silver bromide although, occasionally, a trace of silver iodide is added. Bromide papers, the most sensitive of the printing materials, are 100 to 1,000 times more sensitive to light than chloride papers. This type of graded paper is mainly used for projection printing, due to the lower intensity of the printing light and the distance between the light source and the paper.

The sensitivity of bromide paper is such that even a very weak light source will fog it. Therefore, it should be handled under a yellow-green safelight such as the Wratten 0A. The lamp of the safelight should be no more than 15 watts at a distance of 4½ feet.

Fast chlorobromide papers. The emulsion of fast chlorobromide papers consists of silver bromide and small amounts of silver chloride. This emulsion is not quite as fast as the regular bromide emulsion, yet its sensitivity range is similar. Even though chlorobromide paper is used mainly for projection printing, it requires four times as much exposure as bromide paper. The Wratten 0A safelight should be used.

Exercises (426):

1. Which type of graded paper is most sensitive to light?

2. Which type of graded paper is least sensitive to light?

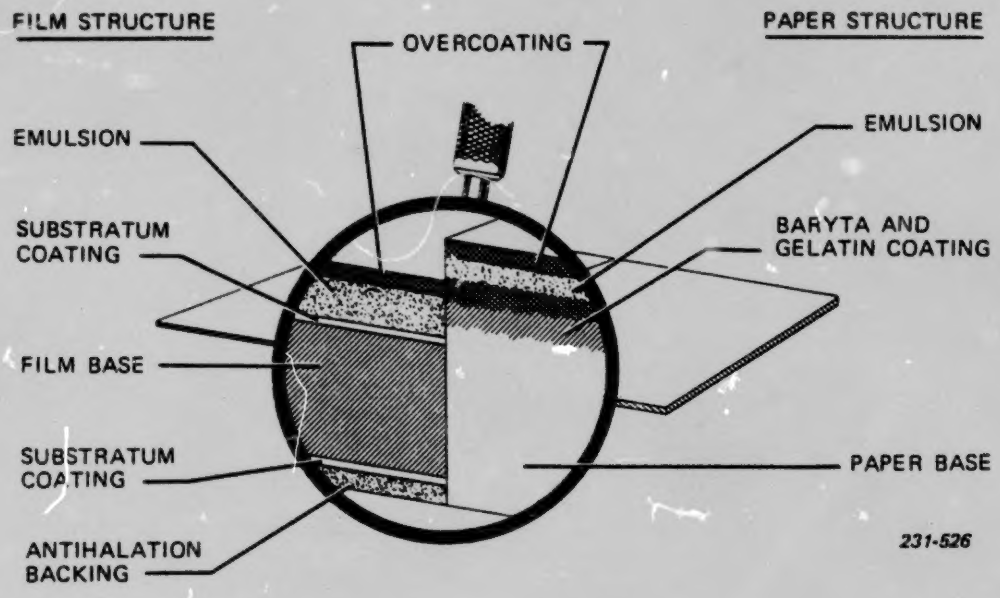

Figure 4-1. Cross-section of paper structure.

3. Which graded paper is primarily suited for contact printing?

4. A Wratten 0A safelight should be used with which type(s) of graded papers?

427. Identify various grades of paper in terms of their contrast ranges.

Contrast of Graded Papers. The term "contrast" is used in the same manner for prints as it is for film. Contrast is the difference between the highlights and the shadows. A low-contrast print is dominated by gray tones, while a contrasty print is dominated by blacks and whites. A normal print should have a variety of tones ranging from white through black.

Since a print is viewed by reflected light, the emulsion must be thin so that only a minimum amount of the incident light falling upon it is absorbed. Hence, there is much less concentration of silver compounds in printing emulsions than in film emulsions. As a result, the emulsion of photographic paper should be exposed normally and developed fully in order to obtain the best print possible.

Contrast, however, is not controlled by development. Instead, your choice of printing papers, which are supplied with a variety of inherent contrasts, is the significant factor. It is not always possible to produce negatives that are exactly normal in contrast. Consequently, variations in printing materials are made to compensate for those negatives that are not normal and to produce the best print possible. These materials are made with several different types of emulsions and each type is adaptable to a negative of a certain contrast. All of these emulsions are designed to record approximately the full range of tones in the negative and yet maintain a pleasing tonal contrast.

Contrast Grades. Most papers are made in several contrast grades. This range of contrast is essential for the photographer, who wants to produce the best possible print from any type of negative—that is, from soft (low contrast) to hard (high contrast). Each manufacturer of printing paper has classified the range of contrasts according to its standards. Therfore, the contrast of a particular grade number and description may not agree with that of another carrying the same identifier. (Paper from the same manufacturer may also vary from one emulsion batch to another and performance may also change with age.) Papers that are currently available conform, in a broad sense, to the following scale:

• No. 0	Extra soft—Normal prints from very contrasty negatives; very flat prints from normal and soft negatives; designed for contact printing.
No. 1	Soft—Normal prints from contrasty negatives; flat prints from normal and soft negatives.
No. 2	Normal—Normal prints from normal negatives; soft prints from low-contrast negatives; contrasty prints from contrasty negatives.
No. 3	Moderately high contrast—Normal prints from slightly soft negatives; contrasty prints from normal negatives.

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No. 4 .....High contrast—Normal prints from low-contrast negatives; contrasty prints from normal negatives.

* No. 5 .....Very high contrast—Normal prints from very soft negatives; very contrasty prints from normal negatives.

* No. 6 .....Extremely high contrast—Normal prints from extremely flat negatives; ultra-high-contrast prints from normal and contrasty negatives.

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*Grades 0, 5, and 6 are not normally available through regular military supply channels

Control of Contrast. The degree of contrast control that can be exercised during printing by exposure/development combinations is very small. (An exception are monocontrast portrait papers that are very sensitive to differences in processing.) Consequently, it is most important to use the correct grade of paper as the contrast control. The wide range of contrasts available is difficult to appreciate without studying actual comparison prints. Hence, during your training, you should produce a series of prints from a normal negative, each one on a different grade of paper. Your tests then can be extended to negatives having a variety of contrasts. These tests will show you the effect of increasing or decreasing original negative contrast during printing by the selection of the appropriate paper grade. By this experience, you will gain an understanding of what you can achieve when given a particular negative to print.

Exercises (427):

1. State the contrast produced by each of the following paper grades: 1, 3, and 5.

2. What contrast grade gives you normal contrast from a normal print?

3. What is the best way to control contrast in prints?

4-2. Variable-Contrast Papers

Instead of stocking a number of different contrast grades, many Air Force photo labs today prefer to use a type of paper that has variable contrast. These papers have one emulsion made up of halides having different inherent contrasts that can be controlled. In this section, we shall discuss the characteristics of this type of paper.

428. Describe the color sensitivity of variable-contrast paper.

Variable-Emulsion Sensitivity. A variable-contrast paper emulsion consists of combinations of halides that are sensitive to either yellow-green light or blue-violet light. The yellow-green sensitive halides control low contrast, while the blue-violet ones control high contrast. The particular degree of contrast is obtained by inserting an appropriate filter between the printing light source and the paper. The filter controls the color of light that reaches the printing paper, thereby controlling contrast.

By using only one type of paper and a set of filters, you can produce finer gradations of contrast than is possible with graded papers. Additionally, you can control contrast of localized sections of the printed image. This can be done by dodging (holding back the light from) all but a particular part of the print when the appropriate filter is in place. Then proceed to dodge the just printed portion when another filter is being used. For example, the low-contrast portion of an image could be improved by printing with blue-violet light, while the harsh part could be softened by printing with yellow-green light.

Exercises (428):

1. Halides in variable-contrast paper are sensitive to what colors of light?

2. What tool is used to control the color of light exposing the variable-contrast paper?

429. Identify the appropriate printing filter to achieve a desired print contrast.

Variable-contrast emulsions are so designed that within a single emulsion you have available varying degrees of inherent contrast. This inherent contrast is controlled by the color of light used to expose the print material. The color of light is, in turn, controlled by the use of filters.

Printing Filters. Each photographic paper manufacturer produces different types of variable-contrast papers and an appropriate set of filters. For example, Kodak manufactures five variable-contrast papers—Polycontrast, Polycontrast rapid, Polycontrast rapid RC (resin-coated), Ektamatic SC, and Portralure (these papers vary in tone, speed, and surfaces, etc.)—and seven filters. The seven filters are numbered from 1 through 4 in increments of 1/2 and progressively change in color from a light yellow (1) to a dark magenta (4). Yellow filters are used to produce low contrast because they absorb blue light and transmit green (and red). The magenta filters produce high contrast because they absorb green and transmit blue (and red). (The paper is not sensitive to red.) Using a number 2 filter or not using any filter will produce normal contrast. Filters are usually made out of plastic or acetate and can be used in contact or projection printing.

After you have selected a suitable variable-contrast paper (for example, Polycontrast) for your printing, you must evaluate the contrast of your negative. A high-contrast negative may require the use of a low-contrast filter, while a low-contrast negative may require a high-contrast filter. If the negative is normal, you can use either a number 2 filter or no filter at all. For example, if your negative were slightly low-contrast, you would choose a number 3 filter. (If you treat the Kodak filter numbers as "paper grades," you will have no trouble in choosing the appropriate filter. Other filter sets may require different selection standards.)

In terms of safelights, the Wratten 0A filter (yellow-green), which is "safe" for graded-contrast paper, cannot be used with variable-contrast paper. Since the paper is sensitive to green, using the 0A safelight would fog it. The safelight filters recommended for variable-contrast papers are the DuPont S-55X (orange-brown) or the Wratten 0C (amber).

Printing filters should be treated with the same care as filters used over a camera lens. A dirty, scratched, or faded printing filter will not do the job.

Exercises (429):

1. Which Kodak printing filter should you use to achieve normal contrast when given each one of the following types of negatives?

   a. Normal negative.

   b. Very-low-contrast negative.

   c. High-contrast negative.

2. What is the range of Kodak filters for variable-contrast papers?

3. Why should you avoid using a safelight with a Wratten 0A filter when producing prints on variable-contrast paper?

4-3. Surfaces of Papers

The final effect of a print depends to a great degree upon the surface of the paper on which it is printed. For this reason, papers are manufactured with a wide variety of surfaces, thus permitting the selection of a surface that contributes the most to the purpose for which the print is intended. In this section we shall cover a few basic surface types you can choose from. The information can be applied to both variable-contrast and graded papers.

430. Define the term "paper surface" and briefly explain why surface selection is important in producing prints.

The wide variety of paper surfaces available makes possible the careful selection of a surface that contributes to the overall visual effect of a print. The surface characteristics of a paper are no less important than tint or tone in producing a print that accurately portrays the subject. (When we speak of tint, we are referring to the range of colors of the print paper stock. The tint may range from a white to a cream, etc. Image tone refers to the developed image color, which may run from blue-black to brown, etc.) The term "surface" refers to the finish and texture of the paper.

The paper's surface influences the amount of light that is reflected from the print. Textures are generally identified as smooth, fine-grained, or rough. There are also specialized surfaces that resemble silk or suede. Many of these special surfaced papers can be ordered from the Federal Supply Catalog, Class 6750. (Paper manufacturers provide paper samplers so that you can see the effect of their different types of papers.) Finish, or brilliance, refers to the shininess of the print, as distinguished from its texture. For example, smooth-textured papers are made in both glossy and matte finishes.

An extremely smooth surface, with regard to both finish and texture, looks bright because it reflects most of the light falling on it. The maximum detail is therefore revealed. A dull textured surface, as is found with matte and some semimatte papers, scatters the light and obscures detail. This scattering not only dims the highlights but also makes the black or dark portions of a print look grayish. However, such a result is less harsh and may add a mood to a picture in which detail is not critical as in scenics or portraiture.

Exercises (430):

1. What is a paper's "surface"?

2. Why is it important to match the paper's surface with the image?

431. Distinguish between different types of paper surfaces.

You will develop taste and judgment in the selection of the appropriate paper through experience. You should start by studying paper samplers put out by the leading manufacturers. After you have an idea of what is available, follow up by printing a suitable negative on a couple of different surfaces to see the effect that each surface has on the resulting print.

The more common finishes are glossy, high luster, luster, semimatte, and matte. We shall limit our discussion here to glossy, semimatte, and matte.

Glossy. The sheen of a particular surface is dependent upon how it reflects the light striking it. Practically all of the light is reflected from a glossy surface. This great amount of reflected light gives maximum detail and brilliance, which are required in many Air Force photographs. A very high gloss, needed for pictures to be reproduced in a base newspaper or other publications (such as this CDC), can be obtained by placing a wet glossy print face down onto a chrome sheet and allowing it to dry. However, to achieve the maximum gloss that the paper surface will produce, you must follow the manufacturer's directions. For example, certain papers must be ferrotyped (dried with the emulsion in contact with highly polished surface), while the new resin-coated papers will air dry to a high gloss.

Semimatte. Semimatte papers have a smooth surface with little texturing. This type of paper dries to a semigloss or flat finish. Semimatte papers are suitable for portrait work and other subjects where maximum detail and contrast are not required.

Matte. The reflected light from matte surfaces is almost completely diffused. These softer, less glaring surfaces are preferred by most photographers for pictorials, portraits, landscapes, and other views not requiring a great deal of detail and brilliance. The smooth paper bases have no pattern. The rougher bases have a noticeable texture that may vary from a slightly pebbled effect to a fabric-like texture resembling linen or a very rough tweed. Smooth papers are recommended for small prints that require good definition and detail rendition. The rougher surfaces subdue fine detail in proportion to the degree of roughness and are useful for prints that do not depend upon detail for interest.

Exercises (431):

Match each description in column A with the appropriate paper surface listed in column B.

Column A	*Column B*
___ 1. Has greatest variety of surfaces.	a. Glossy.
___ 2. Gives maximum brilliance.	b. Semimatte.
___ 3. Has semigloss or flat finish.	c. Matte.
___ 4. Is used for pictures to be reproduced in publications.	
___ 5. Is suitable for a nonglaring landscape in which detail is to be subdued.	
___ 6. Has a smooth surface with little texturing and is suitable for portrait work.	
___ 7. Gives maximum detail.	

4-4. Storage and Preservation of Papers

Photographic papers are perishable and deteriorate with age. They must be protected primarily from the injurious effects of heat and moisture, as well as from harmful gases and from physical damage. Inadequate protection in storage causes increased fog, inferior tone reproduction, and a loss of emulsion sensitivity, as well as such physical defects as shrinkage, distortion, and brittleness.

432. Complete statements regarding procedures for the proper storage and preservation of photographic paper.

Manufacturers package their products either for domestic use or for export. Materials intended for export, or for use when high relative humidity is prevalent, are packaged in moisture-proof containers. Packaging for export is so labeled on individual units as well as on the shipping cartons. Materials intended for normal domestic use may be packaged in moisture-resistant, but not in watertight or vaportight, containers. You should assume that an unlabeled package is intended for domestic use, and you should handle it accordingly. Do not keep sensitized papers under refrigeration once the sealed package has been broken, unless the refrigeration once the sealed package has been broken, unless the refrigerator can be held at 50 to 60 percent relative humidity.

Store individual packages of paper on end so that the weight of the contents is on the edges of the paper. Also, store material with the earliest expiration date to the front of the stack—this procedure enables you to use the oldest material first. However, when it is known that the paper that is due to be used next (according to the earliest expiration date) has been shipped or stored under unfavorable conditions, you should set this material aside and use fresh material for any highly critical project you have to print.

Paper removed from cold storage areas must be adjusted to room temperature over a period of at least 8 hours prior to use; longer times are required for warmup if the packages are stacked.

Processed prints require the same careful protection that processed negatives should receive. Moisture, light, heat, chemical fumes, and careless handling can cause permanent damage. Prints should be carefully

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filed in manila envelopes that are kept in appropriate storage vaults in an air-conditioned room. The relative humidity should be kept between 40 to 50 percent and the temperature near 70° F.

Exercises (432):

Complete the following statements on the storage and preservation of photographic paper.

1. Packages of paper should be stored so that the weight of the contents is on the ______ of the paper.

2. Older paper should be stored towards the ______ of the stack.

3. Paper removed from storage needs to be adjusted to room temperature over a period of ______ hours prior to use.

4. Processed paper needs to be protected from ______, ______, ______, ______ ______, and ______ ______.

5. Prints should be stored in a room having a temperature near ______.

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Black-and-White Emulsion Printing

THE QUALITY of a print can be varied by the choice of printing material, exposure, and processing. Because many of the deficiencies that may exist in the negative can be corrected in the print, it is important that you have a good working knowledge of all the materials and procedures necessary to produce good quality prints.

5-1. Selecting Print Materials

When you are producing either contact or projection prints, it is important to select the appropriate paper for the type of negative you have to work with. The points you should consider in selection are the topic of this section.

433. State some of the principles to follow in the selection of print paper.

Your choice of print paper should be based on: (1) the intended purpose of the photograph; (2) the quality of your negative and (3) the results of paper and negative combinations. Let us discuss each one of these in turn.

The Intended Purpose of the Photograph. In Chapter 4, we discussed the different types of print surfaces and how they are selected in relation to the final product. We want to emphasize again that if you are producing prints that require a lot of detail, choose a paper that reflects the greatest amount. Glossy papers are ideal for this purpose. If detail is not important, then use one of the matte papers. You will have a wide choice of textures to choose from. The basic point is that the paper surface must enhance the image in relation to the mission requirement.

Along with the type of surface, the print tone is also important. Certain papers produce a blue-black tone, while others may produce a brownish color. Mission requirements may call for a certain type of print tone.

The use of a paper sampler can help you choose the right surface/tone combination to meet your requirements.

The Quality of Your Negative. The negatives you are going to print may vary in contrast, density, image (focus and composition), and physical quality (e.g., the presence of scratches). The contrast of your negative may require you to choose an appropriate grade of paper or contrast filter. If the negative is very dense, you may have to choose a "fast" paper to have reasonable short printing times. A thin negative, however, is easier to print on a slow paper. Poor image or physical quality may require you to use a paper with dramatic texture or tone to deemphasize certain defects.

The Test Results of Paper and Negative Combinations. With normal negatives, printing on normal paper is easy. But what happens when you don't have normal negatives, or when you must produce a print having high or low contrast? The answer is: you must make test strips. Selecting the appropriate paper grade then is the result of evaluation of your test strips.

To make a test strip, you must first cut up a sheet of print paper into strips. Then choose an area of the negative that includes the important highlights, shadows, and representative midtones of the subject. Expose each sheet for a different amount of time, noting this time period on the back of the strip. Process each strip in the same manner. Evaluate the strips for density and contrast, choosing the appropriate exposure and contrast grade. Then make a full print. (Test strip procedures will be discussed in greater detail later in this chapter.)

Exercises (433):

Complete the following statements related to selecting print materials.

1. The _____ of the photograph is a factor in selecting a paper with the appropriate surface and _____.

2. The _____ of your negative may require you to use a paper with dramatic _____ or tone.

3. The use of _____ _____ will help you select the appropriate contrast grade when you have abnormal negatives.

5-2. Contact Printing

A portion of your printing requirements can be satisfied by contact printing. Usually, when making a print the same size as the negative, you use a contact printer. Contact printers are ideal for making transparencies and proof sheets (a proof sheet is a print of all of the images on a roll of film). The EN-22A contact printer covered in this section is a manually operated type that you are likely to be using.

434. Complete statements describing a manual contact printer.

Contact Printers. Most manual contact printers used by the Air Force are quite elaborate in their design. Some have a pneumatic (air-filled) bag platen, and others use a vacuum platen to insure contact between the negative and the sensitized material. In some printers, a hand-operated switch automatically turns on the exposing lights when the platen is brought into position and locked.

The lamps in contact printers are usually high-actinic argon lamps for graded papers and incandescent lamps for variable-contrast papers. Depending on design, you may find well over 176 lamps in a single printer. Normally, each lamp is connected to an individual switch so that various lamps, or lamp combinations, can be turned on or off at will. In addition to the exposing lights, contact printers are equipped with safelights and white (viewing) lights.

Automatic timers are even built into some printers. These timers can be set to give any desired exposure, from a fraction of a second up to several minutes. Most printers are equipped with sheets of diffusing glass located between the lights and the negative. These sheets contribute to a diffused, even illumination over the entire surface of the negative when all lights are turned on.

Photographic Contact Printer, EN-22A. The EN-22A, shown in figure 5-1, is a self-contained printer that accommodates negatives up to 10 x 20 inches, and aerial roll film, supported by brackets, up to 9½ inches in width and 500 feet in length. It has 73 3-watt incandescent printing lights. Each light can be individually controlled, and there are pattern switches that control groups of lights. This exact control of lighting permits dodging and burning in of the image. There is also a built-in filter roll for variable-contrast paper. At each end of the filter roll, there is a section of clear acetate, which is used for printing on graded paper.

A sheet of diffusion glass is located directly above the lamps to give diffused, even illumination. Above the diffusion glass is a thick sheet of plate glass on which the negative is placed. Additionally, three other different types of printing glass are provided. These are:

a. One clear printing glass. (You can use your own individually cut masks taped to the glass.)

b. One mask for 9 x 9-inch negatives.

c. One mask for 18-inch negatives.

Exercises (434):

Complete the following statements on the description of contact printers.

1. The negative and the paper are held down by the ______.

2. Precise exposure is available in most contact printers by the control of ______ ______.

3. The EN-22A can handle roll film negatives up to ______ inches in width.

4. A roll ______ is used for printing variable-contrast paper.

5. A sheet of ______ glass is used to provide even illumination.

435. Explain techniques and procedures related to contact printing.

When examined under room lighting, a negative has a shiny side and a dull side. The shiny side is the film base; the dull side is the emulsion layer containing the silver image. A similar examination of photographic paper shows that the paper has a slight curl toward the emulsion and, particularly with glossy paper, the emulsion side reflects more light.

To produce contact prints, the dull side of the negative must be in contact with the shiny side of the paper; that is, they must be emulsion to emulsion. If the negative base is in contact with the paper emulsion, the photograph will be reversed from side to side. In some cases, such a reversal in the print is not readily evident, but it becomes strikingly so if there are letters or numbers in the picture area.

The exposing light must pass through the negative first. Therefore, in a contact printer, the exposing lights are directed upward. The negative is placed on the glass with the emulsion side up, and the paper is laid emulsion side down on top of the negative. Then the lid of the printer box is lowered to press the negative and paper together. (NOTE: To prevent slippage, it may be necessary to tape the negative to the glass. This technique is particularly useful when a large number of prints have to be produced. Later in the

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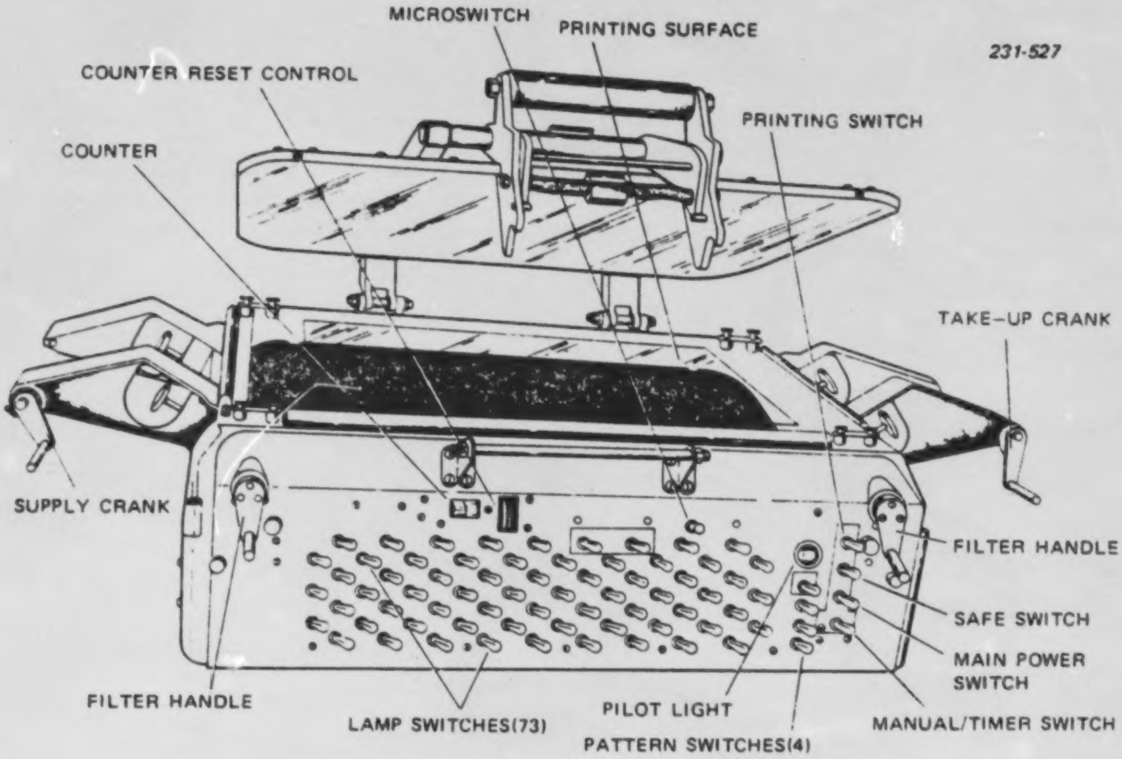

Figure 5-1. Photographic contact printer EN-22A.

chapter, we shall refer to this glass when we discuss the use of masks.)

Earlier we mentioned that contact printing is used to produce proof sheets. A proof sheet is made by printing strips of roll film negatives (35mm, 120, etc.) or individual sheets of cut film on one 8 x 10 sheet. A single exposure is given for all of the negatives. Because this is often a compromise exposure, some negatives will produce poor images. These negatives are separately grouped according to contrast and density; then they are reprinted. Proof sheets are excellent for record keeping and selection of negatives to meet mission requirements.

Remember that the purpose of contact printing is to produce one-to-one image-size prints that reproduce the original scene from the negative as accurately as possible.

Exercises (435):

1. How should the negative and the print paper be placed on the contact printer for printing?

2. How can you determine which side of photographic paper is the emulsion side?

3. In contact printing, how should the size of the image in the negative compare with the size of the image in the print?

4. How should you make a proof sheet?

5-3. Projection Printing

Projection printing differs from contact printing in that the negative is separated from the sensitized paper. The image on the negative is projected by means of incandescent light and an optical system onto the sensitized paper. By altering the negative-to-lens distance and the lens-to-paper distance, it is possible to reduce, maintain, or enlarge the image size. Because most projection prints are made at an enlarged scale, it has become common to refer to projection prints as enlargements and to call a projection printer an enlarger. The preferred terminology is projection printer, since the capability of reduction is present.

Today the skill of making prints by projection has become as necessary to the photographic technician as the making of contact prints. This situation has come about because projection printing offers many advantages over contact printing. The main advantage of projection printing is that the size of the prints can be regulated irrespective of the size of the negatives. Other advantages are the ability to improve perspective, the ease of dodging, the larger choice of projection papers, and the many and varied special effects that can be obtained.

436. State some of the characteristics of projection printers.

Manually Operated Projection Printers. In general, all projection printers are quite similar in design and operation. They consist of an inclosed light source, some method of obtaining an even distribution of light over the negative, a negative carrier, a lens, a means of adjusting lens-to-negative and lens-to-paper distances, and an easel for holding the sensitized paper. It is necessary to have some way of changing the lens-to-negative distance for focusing and lens-to-easel distance for different degrees of enlargement or reduction. The degree of enlargement or reduction of an image is usually measured in terms of diameters. As an example, a two-diameter enlargement is twice the length and twice the width of the negative image (four times the area); and a three-diameter print is three times the length and width of the negative image (nine times the area).

Most projection printers have a tungsten lamp as a light source. The lamp is inclosed in a light-tight housing, which is ventilated to prevent excessive lamp heat from damaging the negative. Some projectors have blowers to circulate air and cool the inside of the lamp housing.

The negative carriers used in the projection printers may be either a dustless type or a glass-sandwich type. The dustless-type carrier consists of two metal plates with an opening in the center large enough to accommodate the negative. The negative is placed between these plates and is held in position by its edges. This type of carrier is satisfactory for negatives 4 x 5 inches in size or smaller, since these negatives have sufficient rigidity to remain flat. The glass-sandwich type of carrier consists of a holder with two sheets of glass, between which the negative is placed. A holder of this type is necessary for larger negatives, since they have a tendency to sag in the center if they are used in the dustless carriers.

The lens used in the enlarger should be free from optical defects and have an angle of field large enough to cover the negative being printed. A lens with a focal length approximately equal to the diagonal of the largest negative to be printed provides a sufficient angle of field.

The bellows of the projection printer should be capable of extending to at least twice the focal length of the lens. This amount of bellows extension is necessary for the production of 1:1 (same size) reproductions. Although it is possible to make reduction to any desired size, the bellows on most projection printers cannot be extended far enough to make image smaller than 1:1. Smaller reduction may be accomplished by substituting a lens of longer focal length.

The methods used to distribute the light evenly over the negative divide projection printers into two general types—the condenser type and the diffusion type.

Condenser-type projection printer. The condenser-type projection printer, shown in figure 5-2, has a set of condensing lenses between printer light source and the negative. The condensing lenses concentrate or focus the light in such a manner that the rays pass straight through the negative to the projection lens. A projection printer with this type of light source reproduces the maximum amount of detail in the print. For this reason, negative defects such as surface scratches very often become apparent on the print. The condenser-type projection printer projects an image that is more contrasty than that projected by a diffusion-type printer.

Diffusion-type projection printer. The diffusion-type projection printer, shown in figure 5-3, has a diffusion medium between the light source and the negative. Light emitted from the lamp, as well as that reflected from the reflector, strikes the diffuser, which, in turn, scatters it in all directions. Thus when the light reaches the negative, it is traveling in no specific direction but in many directions.

The effect of using diffused illumination is that minor negative defects are not clearly recorded in the print. There is a general softening of the image sharpness, which is accompanied by a reduction in image contrast. Diffusion-type printing is favored in portraiture and scenic-type work. However, the overwhelming majority of your Air Force printing will be done on condenser-type enlargers.

Exercises (436):

Complete the following statements regarding projection printers.

1. Fine focusing is primarily controlled by the ______ distance.

2. The degree of enlargement is in terms of ______.

3. Negative carriers are either ______ or ______ types.

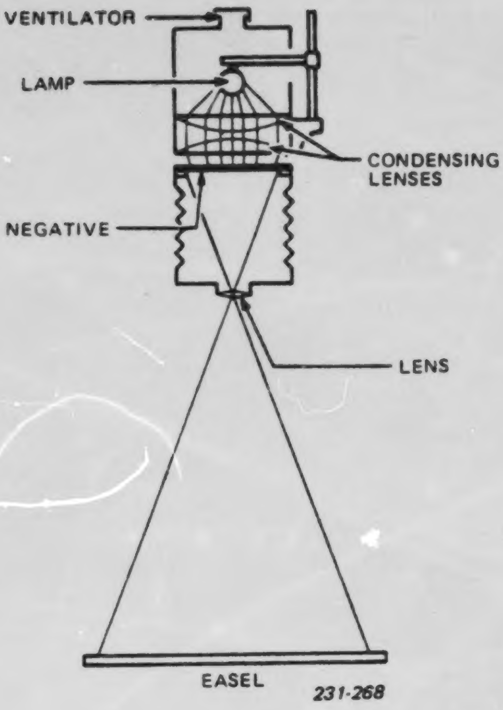

Figure 5-2. Condenser-type projection printer.

4. The enlarging lens normally has a focal length equal to the ______ of the negative.

5. A lens with a focal length longer than the diagonal of the negative geing printed will project a ______ image.

6. A ______-type enlarger will project the more contrasty image.

7. A ______ enlarger is good for printing negatives that have defects.

437. Complete statements regarding the description and operation of the EN-52B projection printer.

Characteristics of the EN-52B Projection Printer. The EN-52B projection printer shown in figure 5-4, is the type of projection printer you will find in your base photo lab. It is a table-size unit used to make enlargements of photographic negatives running from 35mm through 4 x 5 inches. Three lenses are available: f/3.5, 50mm (ideal for 35mm); f/4.5, 100mm (120 or 70mm film) and f/4.5, 150mm (4 x 5). The printer consists of 11 major assemblies. These units are the baseboard, easel, filter wheel, lens, lens cone, lens cup, negative carrier, condenser, lamphouse, carrier, and girder assemblies. Let's take a closer look at a few of these assemblies.

Filter wheel assembly. The filter wheel assembly, mounted just below the lens, consists of a red safelight filter, five variable-contrast filters, and a clear position, all of which are sandwiched between two plates. A knurled nut and a post provide the means for attaching the filter wheel assembly to the bracket of the lens cone.

Negative carrier assembly. Eight negative carrier assemblies are supplied with the EN-52B printer. Spool-type negative carriers are provided for 70mm (glass) and 5-inch aerial roll films. Four glassless carriers, one each for 35mm single frame, 35mm double frame, 70mm, and 120 size, and two glass-type carriers for 2¼ x 3¼ and 4 x 5 inches are also supplied. Each negative carrier consists of a bottom plate and a top plate with a spring-type hinge. The springs serve to connect the top and bottom plates and to hold the negative carrier open when the condenser assembly and lamphouse are lifted or when the negative carrier is removed from the carriage.

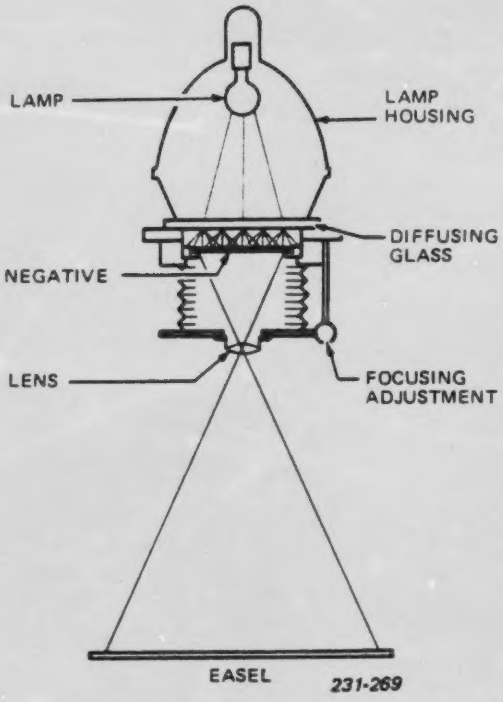

Figure 5-3. Diffusion-type projection printer.

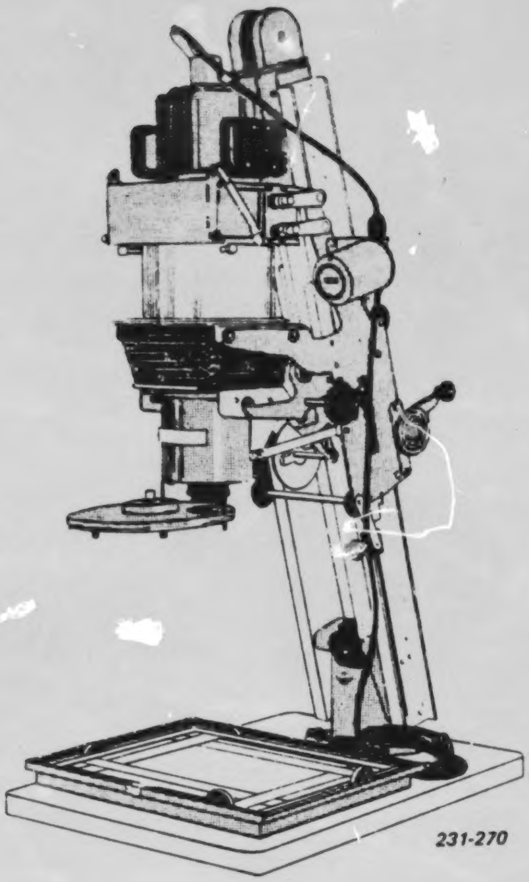

Figure 5-4. Projection Printer, Type EN-52B.

Condenser assembly. Two condenser assemblies are provided with the equipment. One assembly includes a pair of 6½-inch-diameter plano-convex lenses, each having a focal length of 9 inches. The other assembly includes a pair of 5-inch-diameter plano-convex lenses, each having a focal length of 7 inches. The lenses are mounted in a housing with a separator between them. The 6½-inch-diameter condenser assembly is used with the 4½-inch lens cone. Use the 5-inch-diameter condenser assembly with the 2-inch-high lens cup.

Operating the EN-52B Projection Printer. To operate the projection printer, proceed as follows:

(1) Check the movable condenser element to see that it is properly positioned in the lamphouse assembly. Set the cam follower wheel on the cam so that it is matched with the proper lens.

(2) Select a negative carrier of the appropriate size for the negative being printed, raise the lamphouse assembly, and install the negative carrier on the film stage.

(3) Insert the negative with the emulsion (dull) side down on the bottom plate of the carrier. For rollfilm, insert the film in the left bracket assembly of the spool-type carrier, thread and attach it to the empty spool in the right bracket assembly, and rotate the crank handle of the right bracket assembly to bring the desired negative into position.

(4) Lower the lamphouse assembly.

(5) Set the variable-contrast filter turret assembly so that the blank opening is below the lens. Set the lens aperture wide-open by turning the diaphragm control counterclockwise. Turn on and set your timer, which is plugged into the enlarger, on focus.

(6) Place a sheet of white paper in the projection printing easel, loosen the brake knob, and raise the carriage assembly to the highest position by turning the handwheel knob. Focus by making adjustments with the focusing knob until a sharp image is obtained. Adjust the projection printing easel by using the margin control knobs to set each of the masking blade arms. The margin-width markings on the masking blade arms must line up to the dimension of the photographic paper being used.

NOTE: After a sharp image has been obtained, subsequent raising or lowering of the carriage assembly to vary the size of the desired enlargements does not affect the sharpness of the image.

(7) Lower the carriage assembly by turning the handwheel knob until the desired enlargement size is projected on the white paper in the projection printing easel. Tighten the carriage brake knob. CAUTION: To avoid damage to the carriage gears, always loosen the brake knob before turning the handwheel knob.

(8) Set the diaphragm ring to the desired f/stop.

(9) Position the easel to insure that the desired image is composed within the area indicated by the masking blades.

(10) Turn your timer from focus to time. Replace the white paper in the projection easel with a sheet of sensitized paper. The sensitized side must be up, with the top and left edges tight against the margin guides. Lower the hinged frame and make certain that the position of the easel is not distrubed. (NOTE: If variable-contrast paper is to be exposed, set the turret assembly to position the required filter below the lens.)

(11) Make your exposure. (NOTE: The projection printer may be rotated on its base to permit the negative to be projected onto the floor or at an intermediate level in order that greater than normal enlargements can be made. To do this, hold the carriage and girder securely, loosen the three cap screws, and secure the three rotary clamping pads. Rotate the girder 180° on the base and secure it in this position with the cap screws. Remember that before rotating the girder and carriage for projection to the floor, you must secure the baseboard to the table with C clamps to prevent the projection printer from overturning.)

Exercises (437):

Complete the following statements related to the description and operation of the EN-52B.

1. When printing 120 film, you will normally use the ______ mm lens.

2. You can print up to a ______ negative on the EN-52B.

3. The filter wheel is particularly important when printing on __________ paper.

4. A ______ carrier is supplied for 35mm film.

5. To obtain maximum enlargement, it is necessary to ______ the carriage and girder.

438. Explain the techniques used in projection printing.

The prerequisites for good projection prints are good negatives, a clean enlarger, the proper contrast grade of printing paper or variable-contrast paper and filter set, correct exposure, and careful processing and finishing. As you can see, you must control a number of factors in order to achieve top-quality results.

Negative Selection. Although most any negative can be printed by projection, there are a few characteristics that are particularly desirable. A good negative has normal density and contrast. It is sharp and free from such defects as scratches, abrasions, dust, and fingerprints.

Your negatives should be handled carefully in order to prevent fingerprints and smudges that will degrade your image. Lint and dust particles hold back the light during printing, and their shadows produce white spots on the prints, which are very unattractive additions to any photograph. Therefore, both the negative and the negative carrier should be cleaned with a tuft of cotton moistened in alcohol or film cleaner. If the negatives are properly processed and handled, however, they can usually be cleaned with a soft brush, lintless cloth, or air blasts from an aerosol can.

Printer and Easel Adjustments. Place the negative in the carrier so that the emulsion side is down toward the emulsion of the paper. Replace the negative carrier in the projection printer and make sure that it is properly seated.

Adjust the paper corner guide and the masking device on the easel to form the border width and print size needed. As an aid for composition and accurate focusing of the image, place a wheet of white paper in the printing position on the easel. The base side of a finished print serves nicely for this focusing aid. Then turn on the appropriate safelights and turn off the white lights. Turn on the printer light and open the lens to its maximum aperture.

Focusing and arranging the composition of the projected image should be accomplished with the lens wide open. The brighter image is easier to see for accurate focusing. When you are ready to print, you should stop the lens down two or three stops for several reasons. First, almost all lenses project a sharper image when stopped down a couple of stops. Second, stopping down the lens causes a greater depth of focus, which provides a margin of safety for any slight error in focusing. Finally, moderate printing times (e.g., 10 seconds) permit dodging and burning in.

Now take a moment and study the image carefully. (The picture is easier to compose if the scene is right side up. If it is upside down, either rotate the carrier or remove the carrier and reposition the negative.) Most printing papers are rectangular in shape; therefore, you should decide whether to use a vertical or horizontal format. In many cases, the manner in which the scene is composed (horizontally or vertically) on the negative is the controlling factor. Furthermore, most photographs can be improved by cropping.

To bring the image to the desired size, raise or lower the printer head until the approximate size is reached. Then bring the image into sharp focus by changing the lens-to-film distance. However, because the size of the image will be changed slightly by focusing, the printer head should be readjusted. This readjustment involves moving the enlarger head and then refocusing. This operation should be repeated until the desired size is reached and the image is in sharp focus.

After the image is correctly composed and focused, the aperture of the lens should be closed down. Then turn off the printing light, remove the white focusing paper, and place the printing paper (emulsion side up) on the easel. You are now ready to expose and process your test strips.

Exercises (438):

1. What problem will dust and lint cause on your print? How can the problem be reduced?

2. How should the emulsion of the negative and the paper be arranged?

3. For a given negative size, how is image size controlled in projection printing?

4. What two print formats can you normally choose from?

5. In terms of composition, why is projection printing more dynamic than contact printing?

5-4. Masking Borders

The white borders seen on most photographic prints are made at the time the paper is exposed. The masking techniques necessary to insure white borders varies, depending on whether you are doing contact or projection printing.

439. Describe materials and procedures related to printing masks.

Contact Printing Masks. Many contact printers have part of the glass opaqued to form a mask. Thus the negative can simply be taped to the glass for printing. However, in most cases, a mask is constructed from four strips of opaque leader material. These strips are taped together at the corners to form a rectangular opening. As examples of the size of the opening, the mask may be constructed so that the opening is 7½ by 9½ inches for 8 x 10 prints or 3½ by 4½ inches for 4 x 5 prints. A cardboard guide, made to the proper size, can be used as an aid in adjusting the size of the opening and alignment of the individual strips that form the mask. The opening must be a perfect rectangle with square interior edges.

The mask is taped to the printed glass, the negative is taped to the mask, and the paper is placed on top of the negative. This procedure prevents light from reaching the edges of the paper, thereby leaving a white border. The conventional sizes of masks mentioned above produce a 1/4-inch border. However, in addition to the 1/4-inch border, masks may be constructed so that the border is of any desired size or even of a special shape. Masks with odd openings may be constructed for specialized purposes. You may want a circular border on a print, in which case the opening in the mask is round. Or, perhaps you desire an opening shaped like a keyhole or one imitating the effect of looking through a pair of binoculars. Unusual shapes may be effective in newspaper work.

Projection Printing Masks. In projection printing, it is the paper that is masked rather than the negative. An easel is used to keep the paper flat and to form a border. Easels come in a couple of basic designs. One type has a fixed frame for each size of print (8 x 10, 5 x 7, 4 x 5, etc.). Such an easel is immediately ready for use and a piece of paper can be quickly inserted within the frame. Another common type has four masking strips that can be adjusted for any size of print or border. This type of easel has a guide to hold the paper. (There are also borderless, no-masking easels that use vacuum or other means to hold the print flat.) Easels produce square edges and are not meant to be bent into other shapes.

Exercises (439):

1. In contact printing, the ______ is masked; whereas in projection printing, the ______ is masked.

2. What type of material is used to make a contact printing mask?

3. What are the two basic types of printing easels that produce borders?

5-5. Exposure Controls

Determining the correct exposure is as important in printing as it is when the photographer is exposing film in the camera. The basic formula, $E = I \times T$, can be applied to printing. In this case, I represents the intensity of the printing light, and T represents the time the light is allowed to expose the paper.

440. Explain procedures and techniques related to the production of test strips.

The use of test strips is the best method to calculate exposure, whether you are contact or projection printing. Test strips are cut pieces of sensitized material that are each given different exposures. The strips are carefully processed and then compared under white lights. Using strips minimizes waste and insures better results.

When making a test strip, you can apply the following procedures for *either* contact or projection printing.

(1) Before exposing the test strip, choose the area of the negative or projected image that is to be used for the test strips. This area for the test should contain highlights, middle tones, and shadows. Each test strip should be made from the same part of the negative or projected image. Only in this way can one test be accurately compared with another strip. (Unfortunately, when making a projection printing test, too many technicians have been taught to use a full sheet of paper, which is then progressively uncovered. This procedure results in the full image being sectioned off into strips of different density. Thus, there is no way of comparing the strips, since each may represent widely different ranges of negative density and contrast.)

(2) Cut a sheet of number 2 graded or variable-contrast paper into strips that are 2 inches wide.

(3) Carry out a systematic method of exposing, using a number 2 filter for the variable-contrast paper.

For example, you can start with 2 seconds in the case of a projection printer (keeping the aperture the same throughout), and double the time period each time. Another method is to expose each test with an equal amount of increase. For example, 2 seconds could be added to each test. Such a system would give exposures of 2, 4, 6, 8, 10, etc., seconds. The main point is to be sure to bracket the correct exposure; that is, to go from underexposure to overexposure. (NOTE: Using a soft lead pencil, on the back of each strip, identify the exposure time used so that you can know the time that gave you your best result.

(3) After you have exposed and labeled your strips, process them according to the manufacturers' directions for time, temperature, dilution strength, and method of agitation.

(4) As soon as the test strips have been processed, carefully inspect them. By observing the highlight area, determine the best exposure for the grade of paper or variable-contrast filter tested. The highlight areas should be slightly darker than the same paper with no exposure, and they should contain detail. Too little exposure is indicated when there is no detail in the highlights. Too much exposure is indicated when the highlight areas are much darker than unexposed material. If the highlights are not correct on any of the test strips, run a new series of tests (using the same grade of paper or filter), providing more or less exposure as indicated.

(5) When the best exposure has been selected, decide whether the contrast is correct. Do this by examining the shadow area of the test strip that has the correct highlight exposure. If the shadow area of this test is too light, the paper (or filter) does not have sufficient contrast. Either a higher numbered graded paper or a higher contrast filter is needed. If the shadow area is too dark (i.e., the paper has too much contrast), a lower numbered graded paper or a lower contrast filter is needed. (Print contrast is discussed in more detail later in this chapter.)

Remember to continue to make tests until you have finalized the correct exposure time and grade of paper (contrast filter.) It is cheaper to make a number of tests using test strips than it is to go off blindly on a trial-and-error basis with full sheets.

Exercises (440):

1. What is the purpose of making test strips?

2. Why are test strips economical?

3. Explain how to judge proper exposure by observing the highlight portions of a test strip.

4. Explain how to judge proper contrast by observing the shadow portions of a test strip.

441. Explain techniques used to control local exposure in printing.

Local Exposure Control. Many exposures are made under less than ideal conditions and may result in wide variations of density in different areas of a single negative. That is, the exposure in one area of the negative is much greater or much less than in other areas of the negative. This characteristic is usually caused by wide variations in subject tones or the reflective qualities of the subject. In effect, the negative has a greater range of densities than can be reproduced by the printing paper. As a result, you have a negative that is very difficult to print. If the print is exposed long enough to bring out the details in the highlight areas, the shadow areas become overexposed. Or, if you reduce the exposure to retain detail in the shadow areas, the highlights are underexposed and lack detail. Since the objective of Air Force photography is to produce an accurate, detailed representation of the subject, you must often use special printing controls. The two basic controls you will be using are dodging and burning-in.

Dodging. Dodging is reducing exposure (density) in a particular area. The most common and the easiest method of contact-print dodging is through the control of the individual lights under various parts of the negative. The switches controlling lights under the areas of the negative that print too dark are placed in the OFF position. The lights are left burning under the areas of the negative that have the greatest density; thus, these areas of the print get more exposure than the areas of the negative that are above the extinguished lamps. If turning the lights off for the entire exposure time lightens the area too much, they may be extinguished for only a portion of the total printing time. On the other hand, if turning the lights off for the total printing time does not hold the light back enough, lamps surrounding the thin areas of the negative may have to be turned off in addition to those directly below the thin areas.

Dodging can be accomplished more easily and accurately in projection printing than in contact printing. As shown in figure 5-5, dodging may be done by manipulating your hands into various shapes. Or, as shown in figure 5-6, a dodging device can be made by attaching an opaque, properly shaped piece of material to a wire handle. Since the dodging tool is held and manipulated in the beam of light from the lens, its location and coverage can be seen and controlled during the printing exposure.

Dodging is generally necessary for only a part of the exposure time. When dodging, you should consider how close the tool is placed to the lens. The closer the dodging tool is to the lens, the larger the shadow it casts and also the more blurred the shadow becomes.

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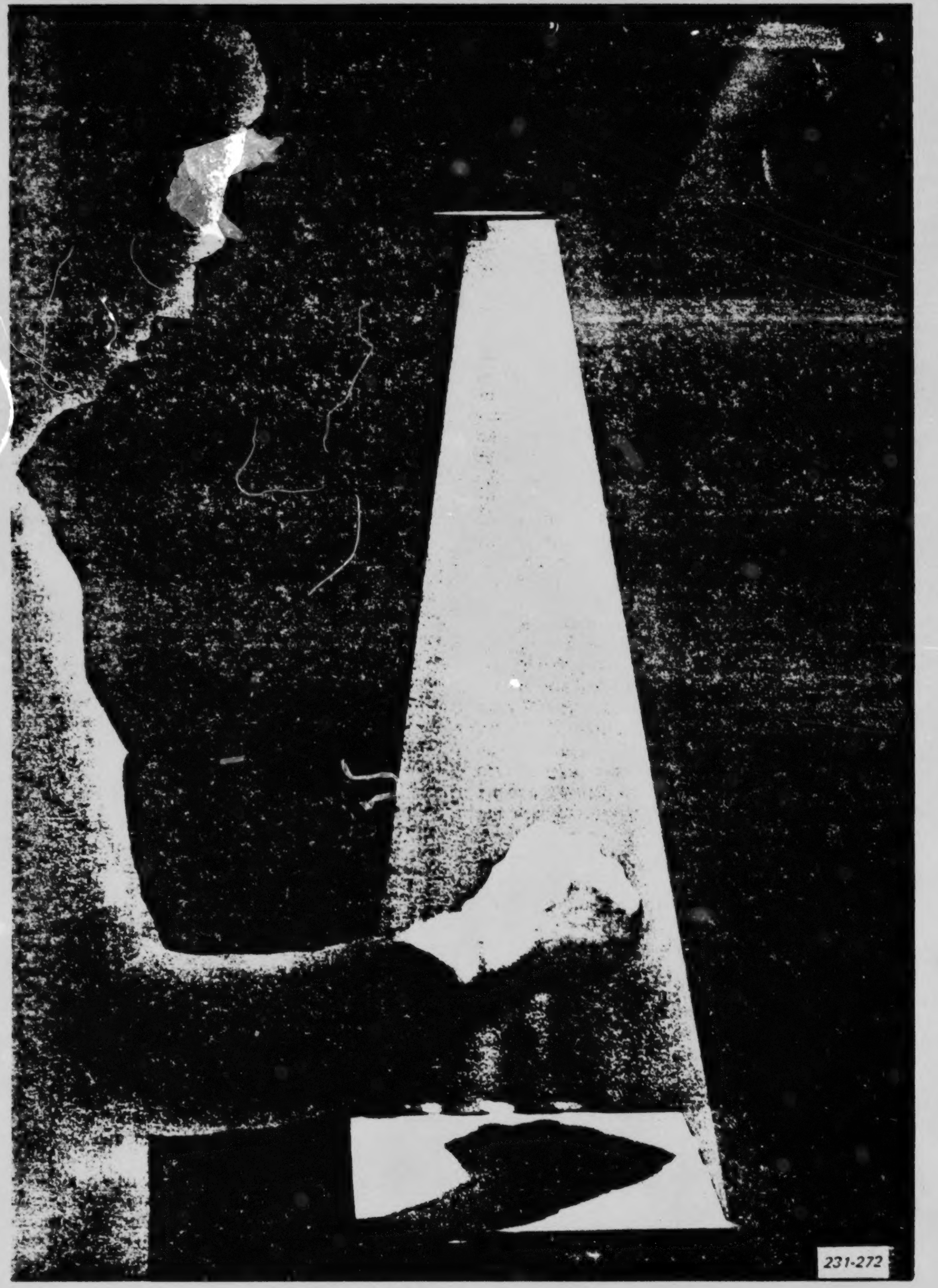


Figure 5-5. Dodging procedure using the hand as a tool.

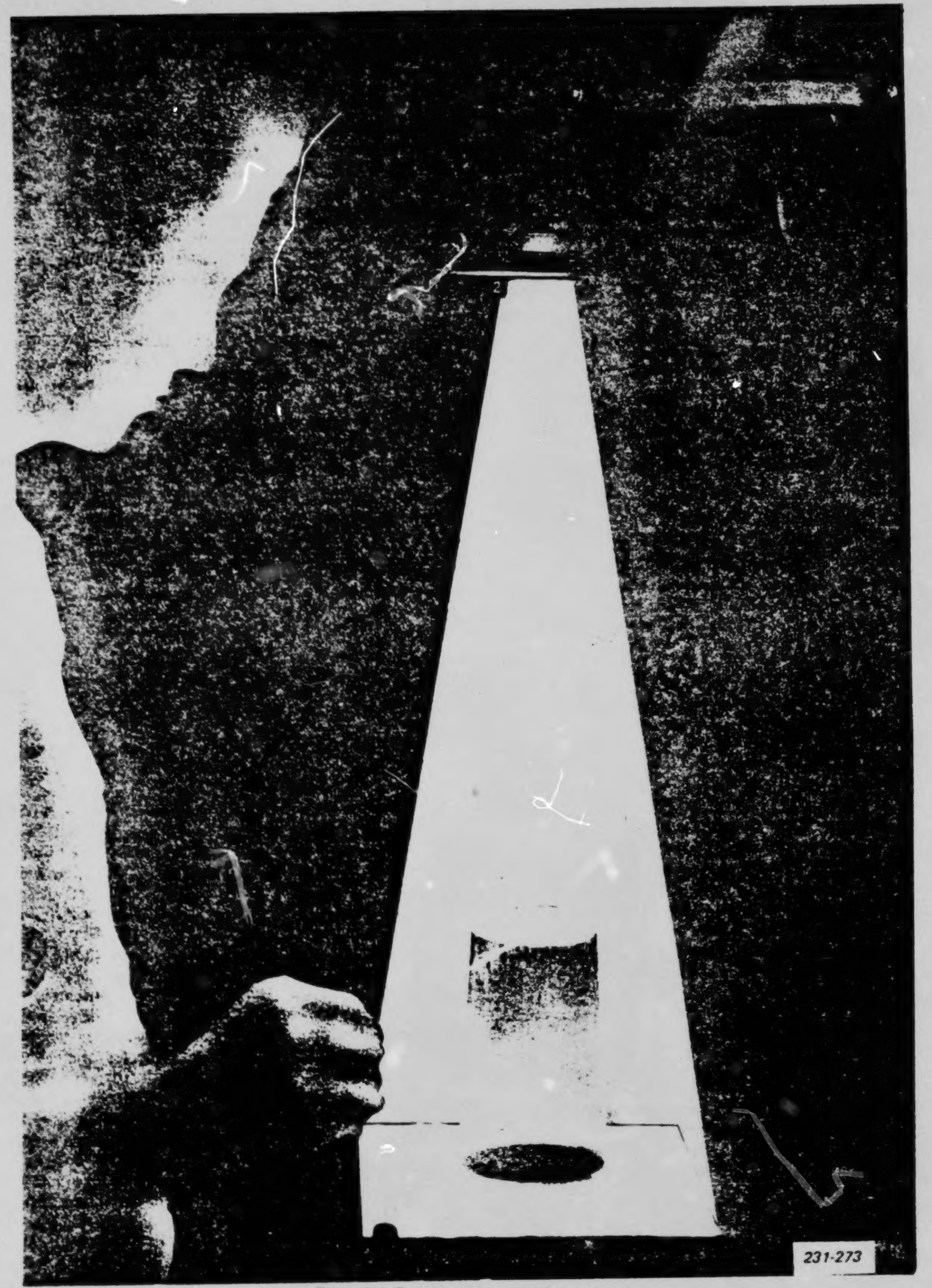


Figure 5–6. Dodging using a manufactured tool.

Conversely, the shadow will be smaller and sharper, the closer the tool is held to the paper. To prevent the formation of a dodging tool outline on the print, the dodging device must be moved up and down and from side to side slowly and constantly in order to blend the areas receiving various exposures.

Burning-in. Burning-in adds exposure (density) to a local area of the print. Normally it is done after the basic exposure has been given to the entire print. In contact printing, the technique is little used but can be accomplished by turning off all the lights except those under the area to be burned in.

In projection printing, burning-in is done by using a piece of cardboard slightly larger than the print; the cardboard has a hole in the center, which is smaller but approximately the same shape as the area to be exposed. Figure 5-7 shows a simple device in use. After the normal overall printing exposure has been made, the burning-in device is moved into position between the lens and the easel. The card holds back all of the light except that passing through the hole. If the burning-in tool is held high, the circle will be large with blurred edges; if the tool is held low, the hole will appear smaller and have sharper edges. During exposure, the device must be kept moving in order to prevent the formation of an outline of the tool on the print.

Exercises (441):

1. Briefly state the purpose of dodging.

2. How do you dodge in contact printing?

3. What is the purpose of burning-in a print?

4. How do you burn in during projection printing?

5. Why must your dodging or burning-in tool be constantly moved during exposure?

5-6. Tone and Contrast

Deciding on the appropriate tone and contrast of a print requires experience and judgment, since there are a variety of techniques and materials that are available. In this seciton we shall discuss a few points to help guide you in this area.

441. Indicate various factors in determining the tone and contrast in prints.

Tone. The tone of the print primarily depends on the paper/developer combination that is chosen. Many papers are cold and tones tend toward blue-blacks. Other papers are warm, with the tones rendered in shades of brown. To achieve the appropriate tone, it is important to follow the paper manufacturer's recommendations for developer type and processing procedures. Another factor is correct exposure. Insufficient exposure renders the tones too light; too much exposure renders them too dark. (NOTE: As a print finishing technique, chemical toning can be done after the print has been processed in order to produce overall tints of many different colors. Toning will be discussed in Chapter 7.)

Contrast. Contrast is the difference between the highlights and the shadows. Your final print contrast depends primarily on the inherent contrast of the negative, the grade of paper or the filter and variable-contrast paper you have chosen, and the developer. Combining short exposure with longer development to produce high contrast or long exposure and short development to produce flatter prints is possible to a limited degree but is not generally recommended.

Tips on Controlling Tone and Contrast. Consider the following points when deciding how the tone and contrast of your prints should be.

a. Try to duplicate the tone and contrast of the original subject. If the values of the print reproduce those of the original subject, your print is likely to have the proper contrast. How much printing manipulation is necessary depends to a great degree on the negative. If the negative does not reproduce the contrast of the original scene, it takes careful selection of paper, developer, exposure and contrast control techniques (grade of paper, dodging, burning-in, etc.) to obtain the necessary results.

b. Preserve detail in both the shadows and highlights. This preservation of detail is particularly important in Air Force photography because the final product is often needed primarily to provide a detailed rendering of the subject. If the negative is very contrasty, it may take a low-contrast paper, along with some burining-in, in order to get the detail. Of course, if there is no detail in the negative to begin with, there is no way to put it in the print.

c. The picture must fulfill the mission requirements. The use of the final product is the key to deciding what to do. Is the print for the base newspaper where reproduction requirements may call for a less contrasty print? Is it for display on a wall where the impact on the people passing by is very important? (In such a case, you must consider the lighting in the room, the color of the walls, other pictures or decor, etc.) Is it being used in an accident investigation where maximum detail is vital? The variety of uses for the resulting print necessitates your learning a number of techniques and being knowledgeable about all the materials in your lab's supply. Know what you can do with what you have.

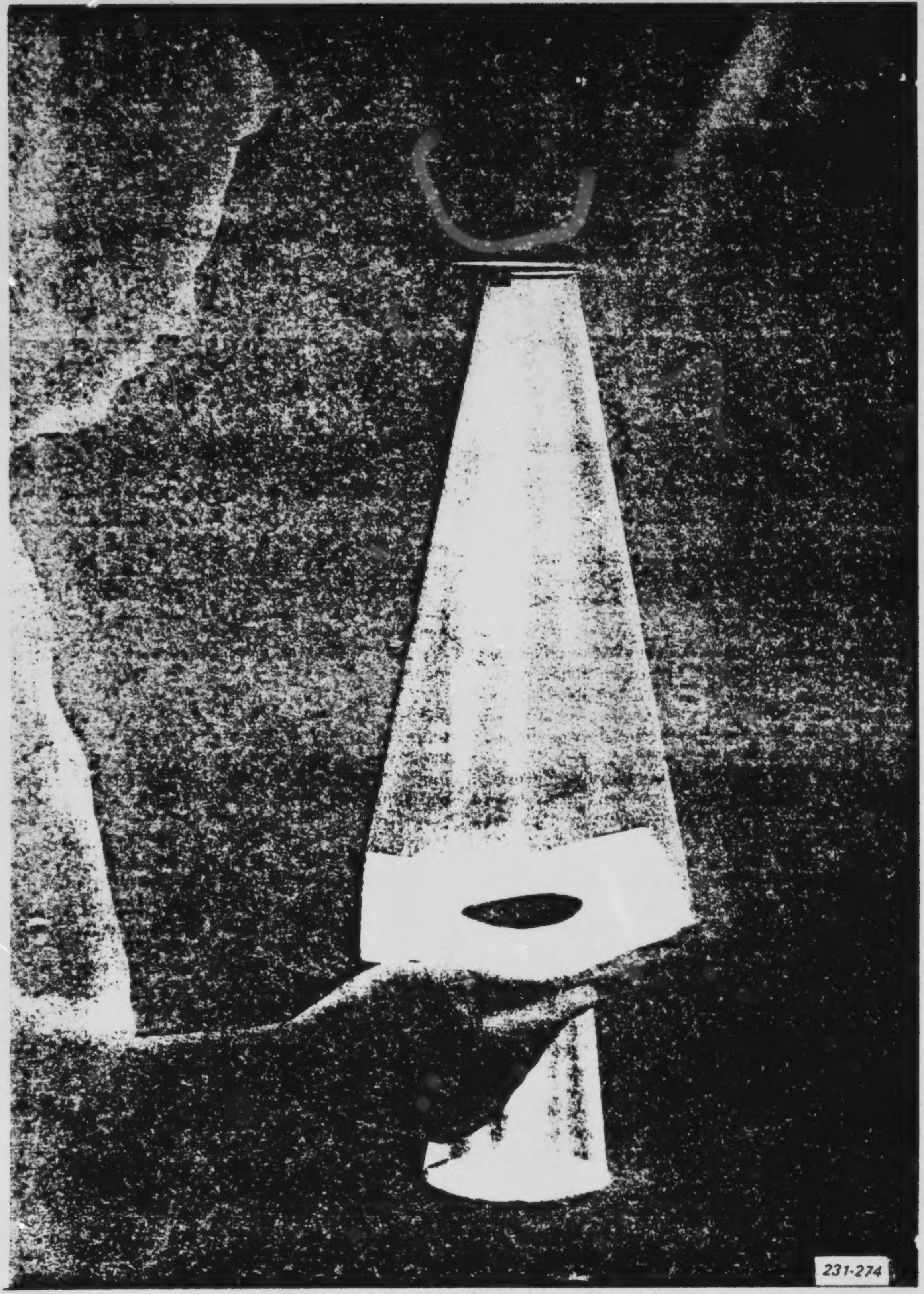


Figure 5-7. Burning-in.

Exercises (442):

1. Define print tone.

2. Define print contrast.

3. Describe how the print is controlled by the choice of materials and techniques that are used.

4. List three important factors in controlling print contrast.

5. Why must you consider mission requirements as you carry out your printing work?

443. Given a series of printing situations, choose the appropriate printing filter to achieve the required contrast, and state proper procedures related to the use of variable-contrast filters.

Using Variable-Contrast Printing Filters. To meet their printing requirements, the majority of base photo laboratories are standardizing on variable-contrast paper rather than graded paper. To control contrast with this type of paper, you must use variable-contrast filters.

As we mentioned when we were discussing print materials, variable-contrast papers have orthochromatic sensitivity. The blue-sensitive part of the emulsion controls high contrast and the green-sensitive part controls low contrast. By interposing the appropriate variable-contrast filter between the light source and the paper, the contrast can be controlled. Depending on the paper's manufacturer, there are sets of filters running from yellow (for low contrast) through dark magenta (for high contrast).

When making your test strips to determine correct exposure, you need to also determine the contrast. You do this by examining the shadow area of the test strip that has the correct highlight exposure. If the shadow area of this test is too light, the paper does not have sufficient contrast. If the paper has insufficient contrast, a higher-numbered filter is needed. If the shadow area is too dark, the paper has too much inherent contrast and a lower-numbered filter is needed.

Earlier (in Chapter 4) we presented a basic guide in determining the proper graded paper to use to achieve a desired amount of contrast. Now let us examine a similar basic guide in determining the correct filter to use. (The guide below is based on using a 1, 2, 3, or 4 Polycontrast (Kodak) filter. The principles would apply to other makes of filters and to the application of intermediate values such as 1½, 2½, or 3½, etc.)

Filter	*Results*
No. 1	Soft—Normal prints from contrasty negatives; flat prints from normal and soft negatives.
No. 2	Normal—Normal prints from normal negatives; soft prints from low-contrast negatives; contrasty prints form contrasty negatives.
No. 3	Moderately high contrast—Normal prints from slightly soft negatives; contrasty prints from normal negatives.
No. 4	High contrast—Normal prints from low-contrast negatives; contrasty prints form normal negatives.

Figure 5-8 shows a series of prints produced by using the above filters.

When using variable-contrast filters, you should remember a couple of points:

a. The filters are available in acetate rolls for contact printing or as individual filters for projection printing.

b. When in use, the filters should be clean and in good order (not scratched). Like all filters, eventually the printing filters will fade and have to be replaced.

c. When being used, the filter should lie flat to insure even exposure over the entire print.

d. The densities of the filters are indicated by the different numbers. For example, a No. 4 filter is darker than a number 3. This being the case, when printing with a No. 4, your exposure times need to be relatively longer. It is a good idea, therefore, to make additional test strips when you change filters.

e. Some contact printers commonly used by the Air Force are equipped with argon exposing lamps. Since these lamps are very rich in blue and ultraviolet (and very limited in the green and red spectrum), they cannot be used for printing variable-contrast paper. It is possible to modify such a printer by installing white incandescent lamps.

f. As we have previously discussed, dodging and burning-in can be effective in controlling local density. It is also possible to change filters to control local contrast. For example, it might be better to give the print an overall exposure with a number 2 filter and then burn-inthe sky with the aid of a number 3 filter. It is a good idea to work from a full test print to determine the best approach.

g. Study the manufacturer's directions that come with the paper so that you can use their filter/paper combination to best effect. (As we indicated early in this volume, too many of us are guilty of throwing away the manufacturer's directions that come with our photo materials. By keeping them in a reference book, we could have a tremendous source of information that would save our time and materials.)

Exercises (443):

1. Determine the correct Polycontrast filter (1, 2, 3, or 4) to be used in the following printing situations.

   a. You have been given a soft negative that must be printed to a high contrast.
   b. A contrasty negative must be printed to normal contrast.
   c. A normal negative must be printed to very high contrast.
   d. A low-contrast negative must be printed to normal contrast.
   e. A low-contrast negative must be printed to low contrast.

2. What type of variable-contrast filters are used in contact printing?

3. How should filters be maintained for printing?

4. What can't you use argon lighting in variable-contrast printing?

5-7. Composition

Composition is the most visually effective way of arranging the various elements of the subject. When you make a print, the subject arrangement is set by the ngative; but how much of the subject should be included and whether it should appear vertically or horizontally is up to you. In contact printing, you are limited to masking off unwanted edge areas, but in projection printing, you are much freer to determine the size and format of the subject. It is therefore important to consider composition when you print.

444. State basic principles and techniques applicable to printing composition.

Since photographers are of infinite variety, and their personal likes and dislikes differ, there are no hard and fast rules in composition. However, the following are some suggestions that can be used to produce a composition that is pleasing to most people. (Remember that the mission requirements of the Air Force must have the ultimate influence on the product.)

a. Normally, the center of interest (subject) is not placed in the middle of the print but a little to the left or right or a little above the center of the print.

b. Horizontal, vertical, or diagonal lines should never be allowed to cut the picture in equal parts. For example, the horizon should be below or above the center of the picture.

c. The horizon should be level.

d. Live subjects should be looking into the picture, not out of it. In other words, there should be more space in front of the figure than behind it. This principle also applies to action photographs: your composition is stronger if the action leads into the photograph and weaker if it leads out of it.

e. Let the subject determine whether it should be printed vertically or horizontally. Tall, thin subjects, such as portraits or buildings, work best vertically. Wide subjects, such as scenics, print better horizontally. If you have doubts, print it both ways and then decide.

To have a clear idea what the best approach would be, make a full-size test print. After processing and finishing, place the print under normal illumination and use L-shaped "rulers" to crop the picture. (The L-shaped cropping guides can be made from cardboard, etc.) Adjust the rulers until the image is the way you want it and then, with a grease pencil, mark the picture. This indication then can be used when you make your final print. (Remember that when you change the image size of the print, you must make new test strips to determine the proper exposure, etc.)

Once you have decided what you want to do, then you can apply a number of different techniques.

The basic technique is to change the size of the image by changing the printer head/paper relationship. As the distance increases, the image becomes larger.

Another way to change image size is to change the focal length of the printing lens. The shorter the focal length, the larger the image for a given negative size.

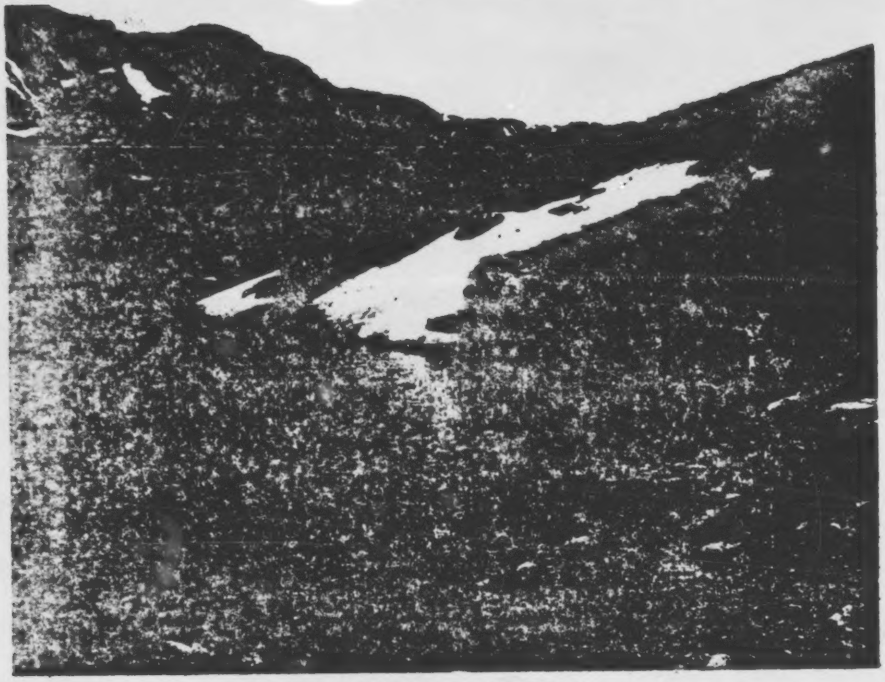
Another technique involves the use of the easel. The easel can be placed horizontally or vertically anywhere within the projected image. It can also be laid at different angles to straighten a horizon line. If you have easels with adjustable blades and you are not held to a certain overall image size, you can crop by adjusting the blades.

NOTE: While not fitting within the topic of composition per se, remember that the tone and contrast of the image greatly affects the way people see your composition.

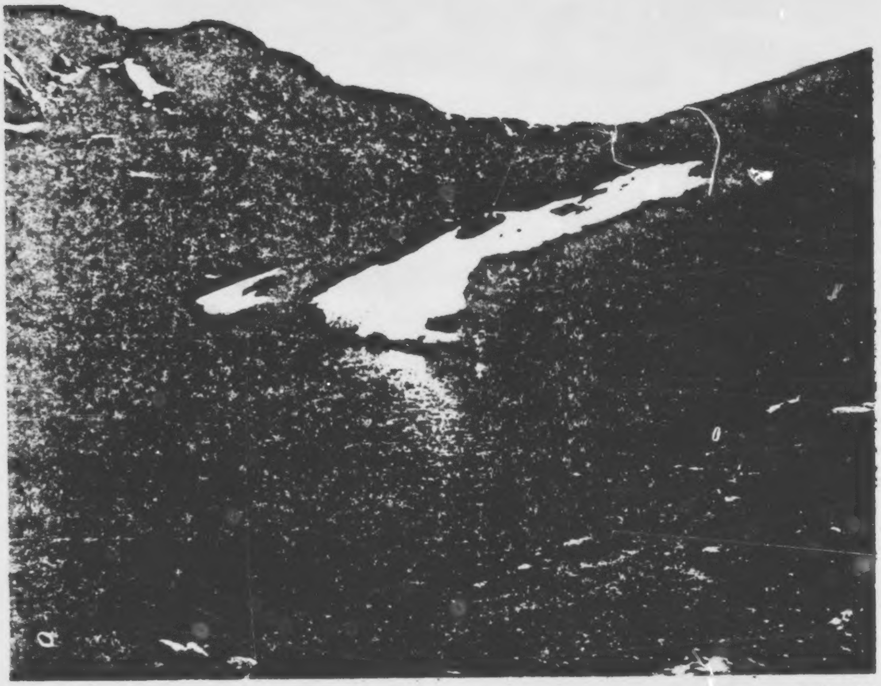
Exercises (444):

1. How should the horizon line appear in a print?

2. How should live subjects be arranged?



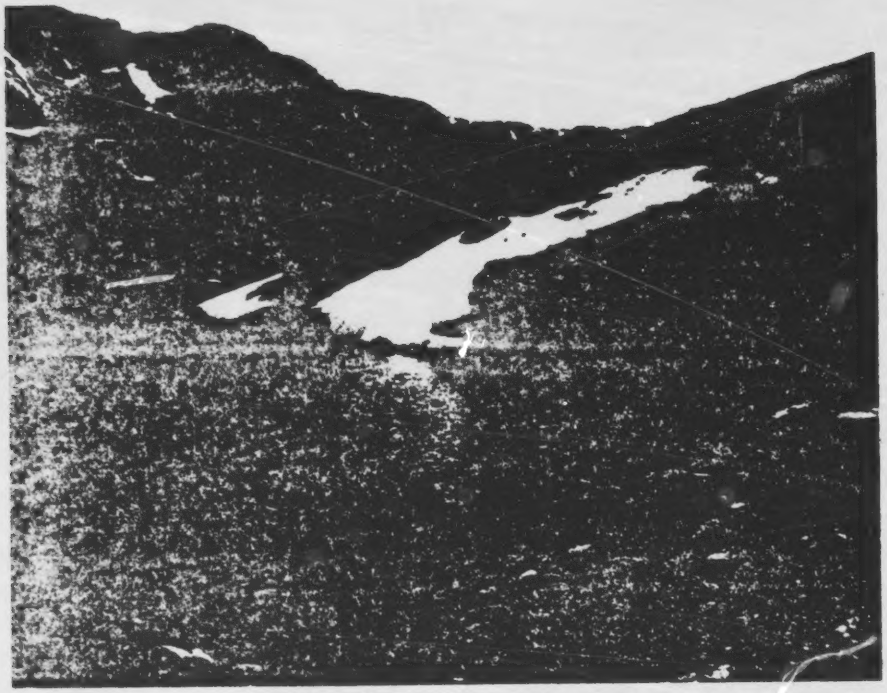
POLYCONTRAST FILTER 1



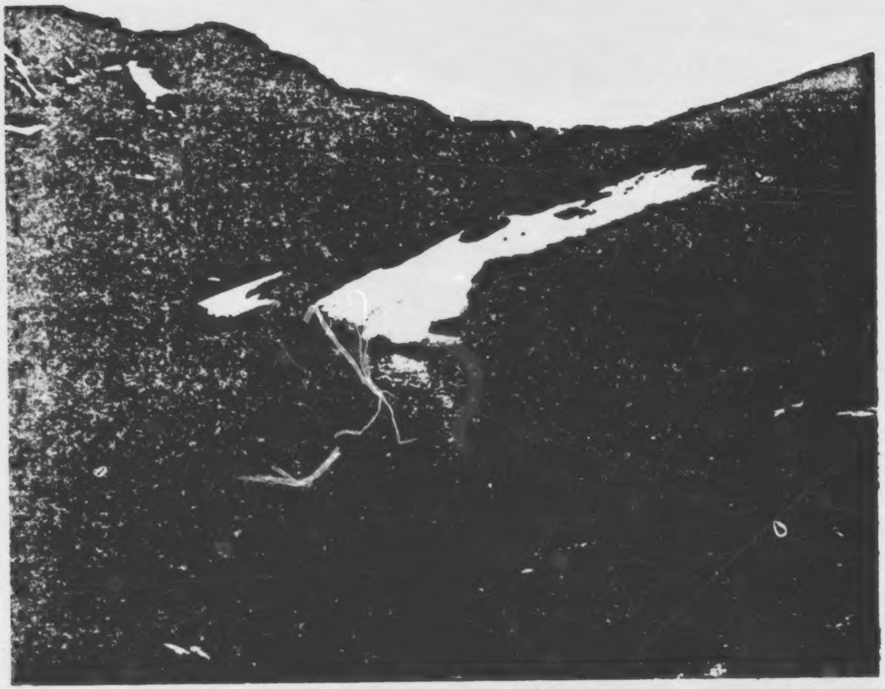
POLYCONTRAST FILTER 2

231-276C

Figure 5-8. Use of Polycontrast filters.



POLYCONTRAST FILTER 3



POLYCONTRAST FILTER 4

231-276D

Figure 5-8. Use of Polycontrast filters (cont'd).

3. What are L-shaped rulers used for?

4. When should you switch to a printing lens with a shorter focal length?

5. What should determine whether the print is horizontal or vertical?

5-8. Distortion Control

Every photographer has discovered what is bound to happen if he tilts his camera upwards while taking a picture of a tall building—the vertical lines converge and the walls seem to be on the point of collapsing. In this section, we are not going to review how to shoot subjects like tall buildings, but we are going to describe how to correct for distorted images when you projection print. (No such correction is possible by normal contact printing.)

445. Describe the proper techniques to use when you must correct for distortion during projection printing.

A view camera is equipped with adjustments that permit making the film nearly parallel with the subject in spite of viewpoint. However, the press-type camera has only a rising front and a lateral shift of the front standard to accomplish any corrective action. Miniature and roll-film cameras rarely have means for correcting the alignment of the film and the subject. As a result of these limitations in taking the photograph, many negatives show a noticeable convergence of lines that is distracting. Changes in these images can be produced by manipulation of the projection printer to achieve the desired correction.

The control of distortion is based on the fact that image size varies with the distance between the negative and the easel. The greater the distance between the negative and the easel, the larger the size of the image produced. Thus, if the image is projected upon an inclined plane or the image is projected from an inclined negative, the portion of the image farthest from the negative will have the largest image size.

Conversely, that portion of the image being closest to the negative will have the smallest image size. If a negative consisting of parallel lines were to be projected from an inclined negative or onto an inclined plane, all portions of the negative would not be the same distance from the paper, and the lines would not be recorded as parallel. By the same token, a negative that has lines that are not parallel (within limits) could be projected so that the print will show them as parallel. The control of distortion is limited to some extent by the type of projection equipment available for making the print.

Tilting Only the Easel. Almost any projection printer has an easel that is a separate entity from the projector. Because the easel is separate, it can be tilted, even if it is merely propped up on one end. Study figure 5-9. Note that a small diaphragm setting is used to increase the zone of sharpness sufficiently to include both the part of the easel nearest the lens and the part of the easel farthest from the lens. Notice, too, that the zone of sharp focus is parallel to the negative in this case, and it is not parallel to the easel.

If parallel lines existed within the negative running in the direction A to B, these same lines on the print would tend to converge—being closest at B′ and the farthest apart at A′. Applying this principle to correct for convergence of lines, the end of the negative having the lines closest together would be placed at end A of figure 5-9. The end of the negative having the lines farthest apart would be positioned at B. (However, realize that the ends of the negative could be reversed if the tilt of the easel were also reversed.)

One of the big disadvantages of tilting only the easel is that an extremely small diaphragm opening must be used to have sufficient depth to the zone of sharp focus. The use of a small diaphragm opening makes it necessary to use longer exposure times.

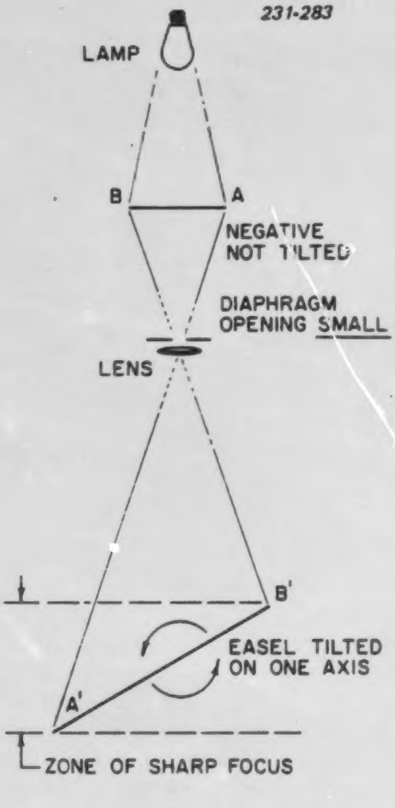


Figure 5-9. Correction by tilting the easel.

Tilting Only the Negative. If the negative were tilted instead of the easel, as is shown in figure 5-10, the result would be much the same as when the easel is tilted. Once again, a very small diaphragm opening would be necessary to produce a zone of focus with sufficient depth to be sharp at both ends of the easel. Notice that the zone of sharp focus tilts on the same axis but in the opposite direction of the tilt of the negative.

Since the same negative-easel relationship exists in figure 5-10 that existed in figure 5-9, the effect of the tilt on the image would be the same as that resulting when the easel was tilted. When the negative is tilted, the same disadvantages also exist; that is, it is essential to use a very *small* diaphragm opening to provide the required depth in the zone of sharpness.

Tilting Both the Easel and the Negative. If you carefully examine figures 5-10 and 5-11, you will notice that if both the negative and easel were to be tilted on the same axis but in opposite directions, the correction would be the same. In addition, the plane of sharp focus would be parallel to the easel. Thus, an arrangement such as that shown in figure 5-11 works very well for the correction of distortion when the distortion is on a single axis. Since the plane of sharp focus coincides with the tilt of the easel, the diaphragm aperature can be relatively large.

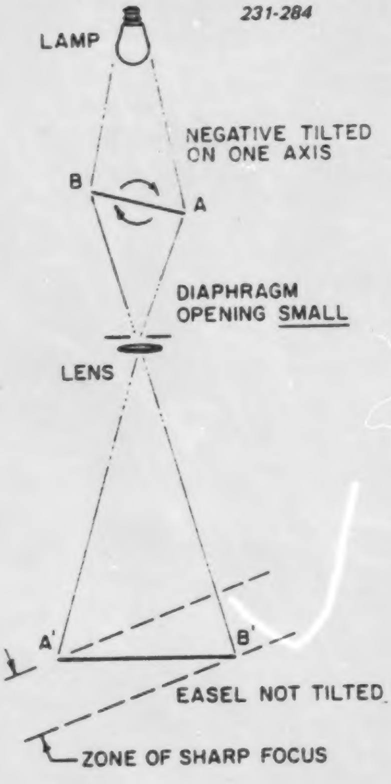


Figure 5-10. Correction by tilting the negative.

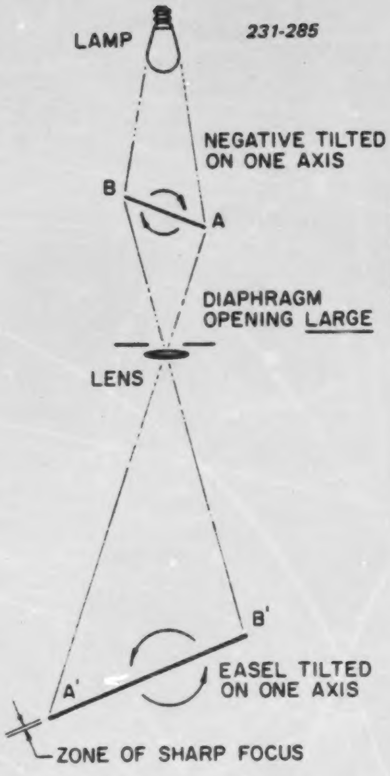


Figure 5-11. Correction by tilting both the negative and the easel.

Not too many projection printers are equipped with negative carriers that can be tilted at will. But remember, many printers are designed so that the entire projection head can be tilted. This tilting, in effect, is the same as tilting the negative. The negative-to-easel relationship is the significant point you must remember.

Tilting Both the Easel and the Negative on Two Axes. Certain projection printers are equipped with both a two-axes tiltable negative carrier and a two-axes tiltable easel. The type of arrangement shown in figure 5-12 is ideal for correction of distortion. Distortion in any direction on the negative can be corrected, and the zone of sharp focus can be made to coincide with the easel in its tilted position. Correction of distortion on both a horizontal axis of the negative and a vertical axis of the same negative is possible. Large diaphragm openings are possible without seriously affecting image quality.

Exercises (445):

Complete the following statements on distortion control.

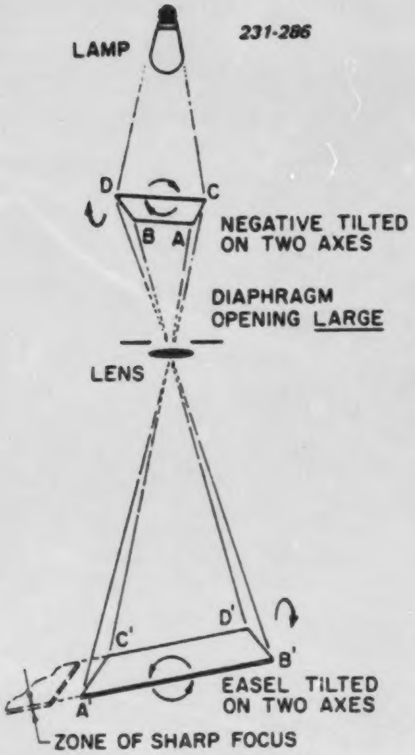


Figure 5-12. Correction by tilting both the negative and the easel in two directions.

1. When tilting only the easel for distortion control, you must use a ______ diaphragm setting.

2. When tilting only the easel to correct for distortion, you tilt the easel ______ where the projected image's parallel lines are farthest apart.

3. When tilting only the negative, you must use a ______ diaphragm.

4. When you tilt both the easel and the negative, you may be able to use a ______ diaphragm.

5. More complete distortion correction is possible when the easel and the negative can be corrected on ______ axes.

5-9. Negative Duplication

Duplicate negatives are often required for distribution to other agencies for printing or for filing and storing in different locations. At times, it may become necessary to send duplicate negatives to other bases for making prints to be used for operational, instructional, or publicity purposes. Duplicate negatives are ideal for training and practicing techniques like etching.

A negative also may be duplicated in order to have a reserve in the event the original is lost or damaged. Duplicating the negative is particularly important when it is impossible to make a new negative of the subject by reshooting it.

In addition, duplicate negatives are used when it becomes necessary to speed up production or when a large number of prints of the same subject must be produced. This mass production can be accomplished by making a number of duplicate negatives of the original and distributing them to the various printing stations. Several technicians can then be simultaneously working to meet production requirements.

Some defects in negatives can be corrected during duplication. For example, you can change the contrast or density of a negative. You can dodge or burn in any local area of the negative. Of course, you cannot impart detail that is not present in the original.

For these and other reasons, you should know how to duplicate negatives.

446. Explain techniques on how to duplicate negatives.

Duplicating by Contact Printer. If the duplicate is to be the same size as the original negative, contact printing is the easiest and most economical method. The positive-negative film method is simple to accomplish. First, contact the negative with a fine-grain copy film like Kodak's Ortho 4125. After the film has been processed and finished, you have your master positive. From the master positive, you repeat the same contact printing steps with your copy film and you can turn out as many duplicate negatives as needed.

To insure good results, remember the following points:

a. The film you use to make your master positive or duplicates may have much different sensitivity than the print papers that you are using. Watch those safelights! Make sure that they are the type recommended for your film. Your exposing times may also be shorter than you are used to.

b. Make sure that the original negative, the master positive, and the film are clean. If you don't, you will have dust spots on the film that cannot be removed.

c. You can dodge, burn in, or change the contrast (by exposure and development combinations) of the master positive. But remember, your aim is to obtain negatives that can produce prints that are as good as (or better than) those produced by the original. Your master positive and duplicate negatives should not normally be high-contrast. They should contain a full range of tones that match the original negative.

d. You should carefully choose your film/developer combination for each step. Duplication magnifies grain, and so by the time you have made your positive and your duplicate negatives, the grain of the original will have been magnified. This magnified grain could ruin your prints. Keep grain down by using fine-grain film/developer combinations.

Duplication by Projection Printing. When the duplicate negative must be a different size than the original, use the projection printer. Projection printing gives you much greater control over dodging and burning-in when you make your master. Once the master positive is made, you can contact print the duplicate negatives.

Reversal Film. An alternative to the positive/negative method is to use reversal film, which can produce the negative in one step. Its drawbacks are the limited number of black-and-white reversal films (mainly 35mm) and the more elaborate processing that is required.

Exercises (446):

1. How can you produce duplicate negatives, using contact printing?

2. What are the advantages of making a master positive by using projection printing?

3. What are the possible drawbacks of using reversal film?

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Black-and-White Print Material Processing

SO FAR WE HAVE discussed printing materials and exposure. In this chapter, we are going to cover print processing, an essential part of turning out satisfactory prints. Our discussion will include darkroom standards, preparation and use of solutions, time and temperature control, proper agitation, and print stabilization. The key to success in this area, as in all other areas of photography, is care in your procedures and pride in your work.

6-1. Darkroom Standards

The darkroom is the photographer's laboratory. As such, it deserves some consideration as to size, location, arrangement, lighting, ventilation, temperature and humidity, sinks, water supply, and equipment.

447. State the principles underlying specific darkroom procedures and equipment for printing.

The location of the darkrooms depend on the available space and the type and amount of work to be accomplished. However, it is obvious that even a small room that is well arranged is an aid to production, whereas a rambling place that is too large is time-consuming. Furthermore, there is less waste, the work is less tiring, and personnel are less likely to have accidents when a standardized procedure is set up and closely followed. Hence, the exposing, developing, rinsing, fixing, and washing of prints may proceed from left to right, or vice versa, but a definite routine should be established.

Darkrooms should be provided with adequate fresh air, and the stale and noxious air should be withdrawn by power blowers installed in the walls. It is also important to maintain darkroom temperature around 70° F. This temperature not only provides a comfortable environment to work in, but is a great aid in keeping the solution temperatures at the right level.

The sinks should be centrally located to save unnecessary steps and time. They should be large enough to hold the largest trays. Tray racks can be placed over the sinks so that any liquid that may splash or spill out runs into the sink and is disposed of through the drain.

Hot and cold running water is absolutely essential. There should be a number of convenient outlets. In addition, there should be a water mixing valve for controlling the temperature.

Darkroom Equipment. The carefully planned printing room should contain the following materials and equipment properly arranged so that the flow of work moves easily from one stage to another: a contact printer or projection printer (or both, etc.), an easel, safelights, a sink and trays for the solutions, graduates for measuring and mixing solutions, a thermometer, towels, at least two pairs of print tongs, an interval timer, and a wall clock with a sweep-second hand. (This list is *not* exhaustive. There should also be suitable multiples of this equipment, depending on the number of workers in the lab.)

Trays. There should be five trays arranged in the sink so that prints can be processed in orderly progression from developer, stop bath, first fixer, second fixer, and water tray. The water tray can hold the prints until they can be placed in the mechanical washer. The trays should be a minimum of 11 x 14 inches for convenient use in processing 8 x 10 prints.

Timers. Most printing rooms contain two types of timers: a large clock with a sweep-second hand and interval timers connected to the contact and projection printers.

The clock timer most often has a black background with a luminous dial (Gra-Lab type, etc.). The dial has a 1-second graduation and a large sweep-second hand. It is normally located on a shelf over the developing tray. It should be used to time each step of the process. (Make sure that the clock is properly maintained. Through use and abuse, the clock can become inaccurate or cease to have a smooth sweep-second hand.)

There are a number of models of interval timers used to time the exposure when printing. Some are built into the printer and others are connected electrically. However, all work on the same principle. The exposure time is set by moving a pointer to the desired time on the dial; the exposure button is pressed and the printing paper is exposed for the given time. When making a number of prints from one negative, this precise timing of exposure will insure greater uniformity of results. A FOCUS button is also provided on the timer to permit the operator to have the printing light on continuously to view the image for focusing and composition.

NOTE: Remember that good laboratory safety requires that all electrical equipment be properly grounded. Many a technician has received quite a shock by simultaneously touching a printer and interval timer when they were not properly grounded.

Print tongs. Most technicians like to use print tongs to hold the print during processing. This technique eliminates the need to handle the print with possible hypo-stained hands that can cause those unsightly white fingerprint marks and require the print to be done over. If you use tongs, keep two points in mind: (1) keep the tongs clean and (2) use two pair of tongs—one pair to handle the print in the developer and carry it to the stop bath and the remaining pair to handle the print through the remaining steps (the use of two pair of tongs is necessary to prevent contamination).

Laboratory Cleanliness. In most photographic publications, there is a section on defects. A close study shows that many defects are caused by a lack of cleanliness in the laboratory. It is much easier and cheaper to maintain a clean laboratory than to spend time, effort, and materials to correct for defects (i.e., spotting prints or reprinting).

Remember to establish a wet side for the solutions and a dry side for the printers. You must keep the dry side dry and free from contaminants. This carefulness insures much cleaner prints.

After processing operations, your hands are wet with water or chemical solutions. In either case, rinse them in clean water and dry them on a clean towel—not one contaminated with chemicals. Be sure that your hands are dry before your return to the dry side.

Avoid splashing chemicals. Splashing chemicals on the floor or your clothing transfers them to the dry side, where they may ruin the prints. Chemicals splashed on the floor may go unnoticed until they dry to a powder. Walking back and forth agitates the powdery crystals and they become airborne. Ultimately these particles settle on your negatives and paper, causing spots that require retouching on negatives and spotting on the prints. Remember, therefore, to clean up all spills as soon as possible.

Regular cleaning of the laboratory is essential to quality production. No area should be overlooked. Floors should be mopped with a dust mop rather than a broom. Then use a wet mop to rinse the floor with clean water. Never use a dirty mop, as this only moves the dirt from one place to another.

When a liquid is used to complete a cleaning job, remember that plain water will remove most chemical deposits. If a solvent is necessary, use as little as possible while following all safety precautions connected with its use.

Cleaning as you go saves time and materials in the long run. No one wants to work in a filthy environment and you certainly cannot produce a high-quality product under unclean conditions.

Exercises (447):

1. Why is it important to have a definite routine to your darkroom arrangement?

2. Why should the darkroom temperature be about 70° F?

3. What are the two types of timers you need when printing? What is each type used for?

4. Why do you need two sets of print tongs?

5. Why is cleanliness so important?

6-2. Preparing and Using Specified Processing Solutions

The proper selection, preparation, and use of your developer is very important to your print quality. In this section, we shall discuss these aspects of the print developer. Then we shall cover similar aspects of stop baths and fixing baths, as well as time/temperature controls.

448. Identify appropriate developers for print processing and explain procedures used in the preparation of a print developer.

Selecting the Print Developer. There are a number of print developers that are available. The developers vary in the tones and contrast they produce and the type of paper for which they are designed. Normally, each manufacturer recommends a particular developer(s) to match each type of paper. In selecting your developer, you must carefully consider the type of paper you are using and the result that you want. Following is a list of Kodak paper developers, their recommended dilution ratios, their processing times, and their purposes. This list is to just give you an idea that several paper developers exist. Other manufacturers would produce a similar list. The basic paper developer in the Air Force is the D-72 (used 1:2 for 2 minutes), which is equivalent to Kodak's Dektol.

Kodak Developer and Dilution Ratio	**Recommended Range of Development Time in Seconds*	*Use*
Dektol (1:2)	45 to 180	Yields neutral and cold tones on cold-tone paper (e.g., Kodabromide).
Selectol (1:1)	90 to 240	Is suitable for warm-tone paper and warmer tones on other paper (e.g., Polylure).
Selectol Soft (1:1)	90 to 240	Is a companion to Selectol but gives lower contrast.
Ektonal (1:1)	90 to 240	Is specially designed for warm-tone papers that are to be toned (e.g., Opal).

*The exact processing time depends on the paper being used and the temperature of the solution.

Preparing Print Developers. Once you have selected the developer you want to use, it should be properly prepared for use. The following points should be considered in making your stock solution. (Once you have prepared your stock solution, you then can prepare your working solution. The working solution is the stock solution diluted, if required, to its processing strength.)

a. Following directions. One of the most important requirements for mixing the developer is to follow the manufacturer's instructions. Failure to follow directions results in solutions that do not perform consistently and properly. This wastes materials.

b. Water supply. Impurities in the water can cause stains. Use filters to remove impurities from the water. Where very critical work is being done, distilled water may be required.

c. Mixing container. The mixing container and the stirring rod that are used must be clean and of the right kind of material to prevent contamination or chemical reactions. Stainless-steel, rubber, polyethylene, glass, and enameled steel are materials commonly used in chemical mixing equipment.

d. Temperature and sequence. To stress the point again, follow the manufacturer's directions regarding water temperature (which may be higher for mixing than for use) and the exact sequence that components are to be mixed.

e. Agitation. Proper agitation (stirring) during mixing is most important to insure that the chemicals are properly dissolved in the water. It is a good idea to introduce only small quantities of the chemical at a time while stirring smoothly but vigorously. (Do not stir so vigorously as to cause the introduciton of air into the solution or splashing of the solution.)

f. Storing. Proper storage is essential to preserve the solution. The developer can be stored in a stoppered amber bottle or an opaque plastic container with a top or floating lid.

g. Safety. Throughout the preparation (and use) of the developer (or any other solution), remember chemical safety. Chemical mixing should take place in a well-ventilated room. Always remember to add the chemicals to water. Do not swallow the chemicals or get them in your eyes. It is a good idea to wear rubber gloves and a face mask to eliminate chemicals hazards.

Exercises (448):

1. Which of the following developers are used in print processing?
   a. D-19.
   b. Dektol.
   c. D-76.
   d. DK
   e. D-72.
   f. Metolflow.
   g. Selectol.

2. What should be your two main considerations when you are choosing a mixing container?

3. What is probably the most important rule in the preparation of a developer?
4. What type of protection should you wear when mixing chemicals?

5. Too vigorous stirring when you are mixing the developer can cause what problems?

449. Briefly explain steps to follow when you are developing a print.

Using Print Developers. Once the stock solution has been prepared, you can make the working solution. The working solution is prepared by mixing the stock solution with the proper amount of water. The working solution then can be poured into the developer tray for processing.

Once your darkroom is all set up, all solutions are at the right temperature, and you have exposed your first sheet, you should follow these steps to develop your print:

(1) Set your wall timer for the processing time. The clock should start once the paper is in the tray. (Some technicians have the clock run all the time and then start processing on any suitable whole minute. This procedure saves resetting the clock or having to start and stop it all the time.)

(2) No presoak is necessary, so you can start right off with the developer. To do this, tilt the tray so that the developer collects on one end. Then slide the paper in, emulsion up. (By so doing, you will prevent the collection of air bubbles on the face of the paper, which could occur if the paper was fed in with the emulsion side down.) Then lay the tray flat, causing the developer to cascade over the paper.

(3) Tray agitation should be continuous, so rock the tray gently throughout the development.

(4) For an accurate 2-minute development (or other time as recommended), lift the paper after 1 minute and 50 seconds of development (i.e., 10 seconds before the end of the development time). Drain the paper for 10 seconds and then slide it into the stop bath. (Accurate timing of your processing is important in order to determine proper exposure. Process by the clock and not by your eyes, as the density of the print under the safelights and in the developer is deceptive.)

A slightly different procedure is used if you are developing more than one sheet of paper at one time. If this is the case, first, put one sheet at a time, emulsion side up, in the developer. Then proceed to agitate by rotation rather than by rocking the tray. Do this by pulling the first (bottom) sheet out from under and putting it face down on top of the stack of prints. Immediately follow it with the next sheet from the bottom and continue until the whole pile is face down. At once, pull them through again, one by one in the same order, to make a face-up pile; continue to flip through the prints this way, carefully and regularly, until the end of the development time. Drain each print prior to putting it in the stop bath. NOTE: To insure consistent timing, it is important to count as you go so that the first print is in the first print out.

Exercises (449):

1. Print processing normally calls for what type of agitation? Why?

2. For a single sheet, how should the emulsion face during processing? Why?

3. What procedure should you follow to insure an accurate processing time?

4. How should you agitate when you have to process more than one print at a time?

450. Indicate characteristics of stop baths and fixing baths, and explain how to prepare and use these solutions.

Once you have developed your print, you need to rinse it in a stop bath and then make the image permanent through use of a fixing bath.

Purpose of the Stop Bath. A stop bath, though it does not make the image permanent, serves three important purposes: (1) it stops or slows down development by neutralizing (a chemical reaction) or diluting the developer; (2) it helps to prolong the strength of the fixing bath; and (3) it helps prevent blisters that would result from the strong chemical reaction between developer on the print and the fixing bath at the very print when the emulsion is soft.

Preparing and Using the Stop Bath. There are basically two types of stop baths that are commonly used. These are water and acid. Plain water is used because it is readily available. However, it acts only as a rinse. It dilutes the developer, but it does not neutralize it (i.e., no chemical reactions are taking place). If you use only water, make sure that you have the water continuously running into the tray to keep it fresh.

Most labs use an acid stop bath because the acid reacts with the alkaline in the developer and neutralizes it. To make an acid stop bath, first make a 28-percent solution of acetic acid from glacial acetic acid. To do this, dilute three parts of glacial acetic acid with eight parts water. To make the stop bath itself, add 1½ ounces of the 28-percent acetic acid to 32 ounces of water. (NOTE: Remember for safety's sake, *always add acid* (AAA rule to the water.)

During use, the temperature of the stop bath should be the same as the other solutions (e.g., 68° F). After development, place the print in the stop bath and be sure to agitate for 15 to 30 seconds (longer if more than one print is treated at one time). Stains may result if prints are merely left to stand in the solution.

For best results, read the instructions that come with the paper that you are using. The instructions outline the type of stop bath to use and the time the print should remain in the bath.

Purpose of the Fixing Bath. The fixing bath is important because it chemically changes undeveloped silver (exposed or unexposed halides) into soluble salts that can be washed away. If undeveloped silver halides were to remain in the paper, they would discolor when exposed to light to which they were sensitive. This discoloration would result in fading of the image.

Preparing and Using the Fixing Bath. There are two types of hypo solutions in common use: one with and the other without hardener. For average use, the packaged hypo with hardener, mixed with water according to the manufacturer's directions, is advisable. The purpose of the hardener is to prevent excessive swelling or softening of the emulsion. It is particularly important when you are processing at high temperatures. If you want to give your prints a post-processing treatment, such as toning, you should make your own fixing bath without hardener. The Photo Lab Index gives you formulas for these fixing baths.

In preparing to use a fixing bath, take a stock solution of hypo as your working solution (no dilution necessary). Prepare a setup of two fresh fixing baths. (When the first bath is exhausted, usually after processing two hundred 8 x 10s per gallon, replace it with the second fixing bath. A fresh bath then replaces the number two bath.) The exact amount of time in each bath varies with the particular fixing bath, its temperature, and the paper being processed; but normally it would be 3-5 minutes per bath. (Kodak has come out with a new resin-coated projection paper that can be fixed in 2 minutes.) The length of time in the bath is important because too much time can cause bleaching and too little won't do a permanent job. The temperature of the bath should be similar to the other solutions. Proper agitation is also very important; without it, uneven fixing may result.

A print can be examined under a white light after it has been properly fixed for 2 minutes.

Exercises (450):

1. Why is a stop bath an aid to accurate development times?

2. What is the main advantage of an acid stop bath over a water stop bath?

3. How long should a print stay in a stop bath?

4. What is the purpose of a hardening fixing bath?

5. What is the advantage of using resin-coated paper?

451. Explain the relationship between development time and temperature in print processing.

Establishing Time/Temperature Controls. Just as in film processing, the factors of solution temperature and the length of time the sensitized material is in the solution are important factors in determining the quality of the result. If the paper is developed for too short a time or at too low a temperature, a weak, low-density, low-contrast print will result. Underdevelopment can result in a loss of detail in the highlight portion of the subject. On the other hand, if the print is developed for too long a period or at too high a temperature, the result will be a print with too much density with a slight increase in contrast. Extreme overdevelopment can lead to fogging.

The ideal procedure to control your processing time is to establish temperature control of all your solutions. By having all the solutions at the recommended 68° F, you can follow through with the recommended times. This control can be established by using a thermometer to check the temperatures and a water mixing valve to get the water for mixing the solutions to the right temperature.

If you cannot establish a temperature of 68° F, you must modify your processing times accordingly. Check the instructions that come with your paper or developer for a time/temperature chart that gives the appropriate time for the temperature you are using.

Exercises (451):

1. What is the relationship between time and temperature when you are processing a print?

2. How can you establish temperature control of your solutions?

6-3. Agitation

Agitation is very important in every step of print processing. We have mentioned it on a continuing basis throughout the chapter, but now we should like to explore it further to emphasize its importance in correct processing.

452. Explain principles and procedures related to the agitation of prints during processing.

Purposes of Agitation. Agitation is important in every step in processing, but its importance can be comprehended best by understanding what takes place during development. During development, the solution reduces the exposed silver halide grains in the emulsion to metallic silver. In the process, a number of oxidation and chemical by-products are formed. These by-products will retard development if not replaced by fresh solution.

When you have stagnant development (no agitation), some portions of the solution are richer in by-products than others, due to the fact that at regions of high exposure, more development takes place than at low exposure regions. For this reason too, development is retarded to a much greater extent at regions of high exposure than at those of low exposure. A lack of agitation also produces development mottle (streaks). This defect occurs because the diffusion of fresh developer and reaction byproducts from within the emulsion take the path of convection currents. In the unagitated solution, these currents take slow, random, irregular paths, producing uneven development.

This same effect can take place in the other solutions. Improper agitation in the fixing bath can lead to stains and uneven fixing that will result in fading as time goes on.

Air bells can also be eliminated by proper agitation. Air bells are tiny bubbles in the developing solution, which can cling tenaciously to the paper emulsion and cause small circular or eliptical clear spots to occur. A spot having soft edges or one of low density indicates that the bubble grew smaller as development progressed or broke before development was completed.

Methods of Tray Agitation. When processing a single print at a time, you can agitate each of the solutions by continuously rocking its tray. For the fixing bath, you should have continuous agitation for the first 2 minutes; you should then agitate at least once every minute after that.

When working with more than one print, you move the prints rather than the tray, leafing each print in rotation from bottom to top throughout the processing. It is important to count each print as you go, so that you can transfer the prints in order from one solution to another.

Exercises (452):

1. What is formed during processing, thereby making necessary a continuous replacement of fresh developer?

2. What is mottle? How is it caused?

3. What are air bells? How do they affect a print?

4. When processing a single print, you agitate by moving the ______; when processing groups of prints at one time, you agitate by moving the ______.

6-4. Print Stabilization Processing

Stablization is the term applied to photographic printing that uses developer-impregnated paper. This paper is then processed by using an activator chemical for development and a stablizer to "fix" the image. Special materials and processing equipment have been produced for this purpose. This section will describe the basic principles of stabilization processing as they are related to the Ektamatic SC paper and the Ektamatic Model 214K processor. This system has great value in newspaper work or whenever speed is a prime requisite for mission success.

453. Complete statements regarding principles, procedures, equipment, and materials related to stabilization processing.

Paper for Stabilization Processing. The paper and emulsion used for stabilization processing is similar to that used in conventional processing. However, this type of paper is not available in as many variations of weight, sensitivity, and surface characteristics as normal paper. The primary difference is that the paper is impregnated with a dry developing chemistry. Kodak's Ektamatic SC paper is virtually identical to Polycontrast paper except for its processing ability. Its contrast is controlled by variable-contrast filters. You use the same Wratten 0C safelight.

Processing Methods. Ektamatic SC paper may be processed by conventional paper processing methods using standard developer and fixer solution. However, the advantage of rapid processing necessitates use of special chemistry with this paper. Only two solutions are required to produce a visible, *semipermanent* image on the conventionally exposed paper: an activator solution and a stabilizer solution.

The *activator* solution reacts with the developer-impregnated paper to convert the latent image into a visible silver image. A short stop or rinse bath is not required before stabilization. The *stabilizer* solution neutralizes further effects of development and greatly reduces the emulsion's sensitivity to light. Note that the light sensitivity has been *reduced* but not completely neutralized. The resulting degree of permanency of stabilized prints, therefore, depends on the extent of their exposure to heat, light, and humidity. This characteristic is not usually detrimental. Stabilization-processed prints normally are produced for short life requirements such as proofs or for immediate reproduction by news media.

To insure the permanence of Ektamatic SC paper, it must be fixed, washed, and dried by conventional methods. Stabilization processing equipment, such as the Ektamatic 214K, squeegees the prints through rollers after they have passed through the stabilizer solution. The paper then is in a damp-dry condition with a semigloss finish.

Complete drying occurs within a very few minutes at normal room temperatures. A glossy finish is possible only after drying with normal print-drying equipment.

Since this drying method normally requires heat, the print must be fixed in conventional fixer and then washed in order to prevent image deterioration. Procedures for obtaining permanent images are explained in the data sheet supplied with each package of paper.

Ektamatic 214K. The model 214K Kodak Ektamatic Processor was designed to process exposed stabilization photographic papers up to 14 inches in width. The two solutions are supplied in plastic bottles and no chemical mixing is necessary. The processor should be positioned on a stand or table or in the processing sink.

Power source. Normal power requirements are 115-volt, 60 cycles ac. Choose a convenient outlet to connect the three-pronged plug of the power cord. As with all electrical equipment used in photo, it is important that the machine be properly grounded.

Assembling and leveling the processor. Be sure that all items are carefully unpacked. Remove the processor base and solution tray, shown in figure 6-1, from the shipping pallet. Insure that all the items are present by checking each against the packing list.

After lifting off the solution tray, wipe it down with a damp sponge to remove any foreign material. Assemble the four leveling feet to the processor.

Insure that the two drain bottles are inserted into the base of the processor, as shown in figure 6-2. Using the tray location hole, replace the solution tray on the processor base. Insert the ends of the drain bellows (see fig. 6-1) into the drain bottles.

Level the processor (side to side and front to rear) by rotating the leveling feet. Use a spirit level on the center partition to check the side-to-side adjustment; span with the width of the tray to check the front-to-rear adjustment.

Leveling can also be done by filling the front section of the solution tray with water and adjusting the leveling feet until the water is at the same height along the entire length of the center partition. Compare the water level against the height of the flat surfaces near the front drain bellows for front-to-rear leveling. Drain the water from the tray by depressing this drain bellow. Take out the solution tray and empty the drain bottle. Replace the bottle and the tray.

Assemble the driven gear, shown in figure 6-3, to the roller shaft on the processing rack assembly, using the drive pin and washer. This gear will mesh with the adjacent rack gear when it is assembled properly. Wipe the processing rack assembly with a damp sponge.

As shown in figure 6-4, place the processing rack assembly on the solution tray. Be sure that the corners of the processing rack assembly rest in the recesses of the solution tray. After making certain that the rack gear is meshed with the base idler gear, snap the hold-down latch over the shaft.

Assemble the housing assembly (fig. 6-5) on the processor by tilting the front upward and toward the

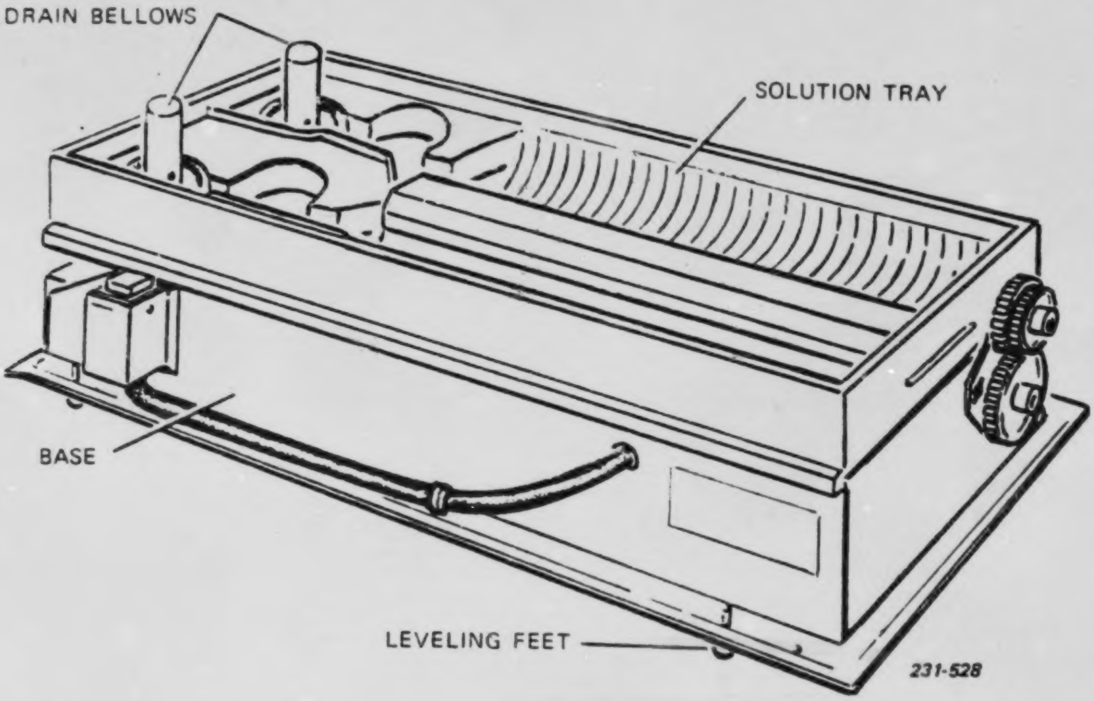

Figure 6-1. Base of Ektamatic 214K Print Processor.

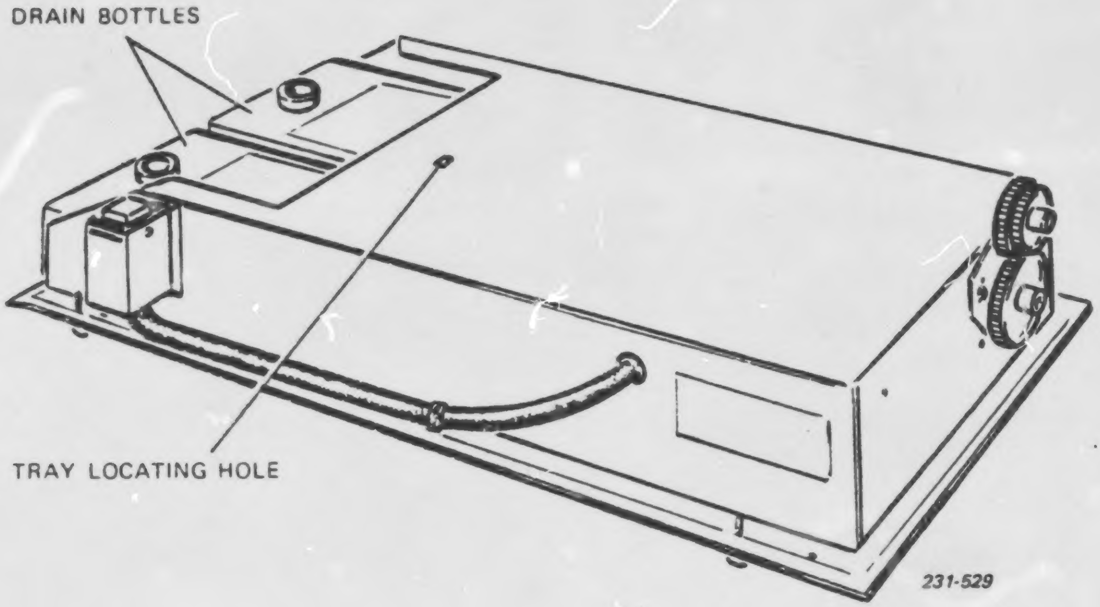

Figure 6-2. Drain bottles inserted in the processor base.

rear of the processor, hooking the rod under the two brackets fastened at the rear of the processor base and then lowering the front of the housing assembly.

Insert the feed shelf through the processor housing, as shown in figure 6-6, tilting the front upward, inserting it as far as it will go, and then lowering the assembly. This action hooks each end of the shelf to the tie rod.

Operation of the processor. The operation of the 214K processor requires specific attention to the chemical solutions, the starting and stopping procedures, and operator maintenance. The first step is to install chemical supply bottles. After removing the caps from the 1-quart solution bottles, install a solution-level valve to each bottle, as shown in figure 6-7. Tighten each valve securely. Always be sure to use the black solution-level valve with the activator and the red valve with the stabilizer, thus preventing the possibility of contaminating the solutions.

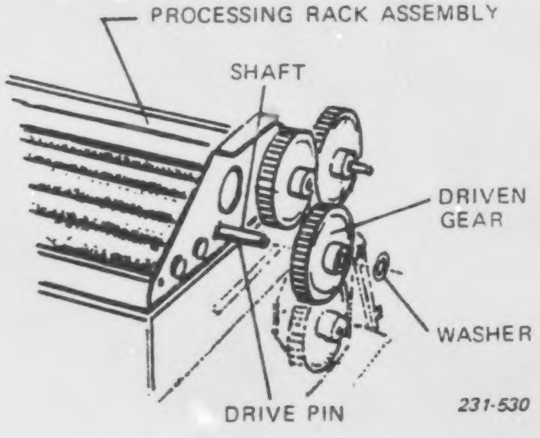

Figure 6-3. Drive gear mechanism of the processor.

With the bottles held above the processor, turn them upside down and quickly insert them into the openings provided in the processor. Be sure that each chemical bottle is inserted into its proper hole (i.e., the activator into the opening marked "Activator," and the bottle of stabilizer into the opening marked "Stabilizer", as shown in figure 6-8. Check that both bottles are seated firmly in the tray. When the processor is first started, slightly less than 1 quart of activator and slightly more than 1 quart of stabilizer are required to fill the trays. When a bottle is empty, install a full one.

To start the processor, press the start-stop button, shown in figure 6-8. When the light in the button is on, the processor is on. When the processor is to be used frequently, the drive can be left running.

CAUTION: Be very careful not to touch the emulsion side of the paper before processing. To avoid chemical contamination of the feed tray, be sure that the processed prints do not come in contact with the tray or housing as they are removed.

Always insert the exposed paper emulsion side down. The paper should also be inserted lengthwise

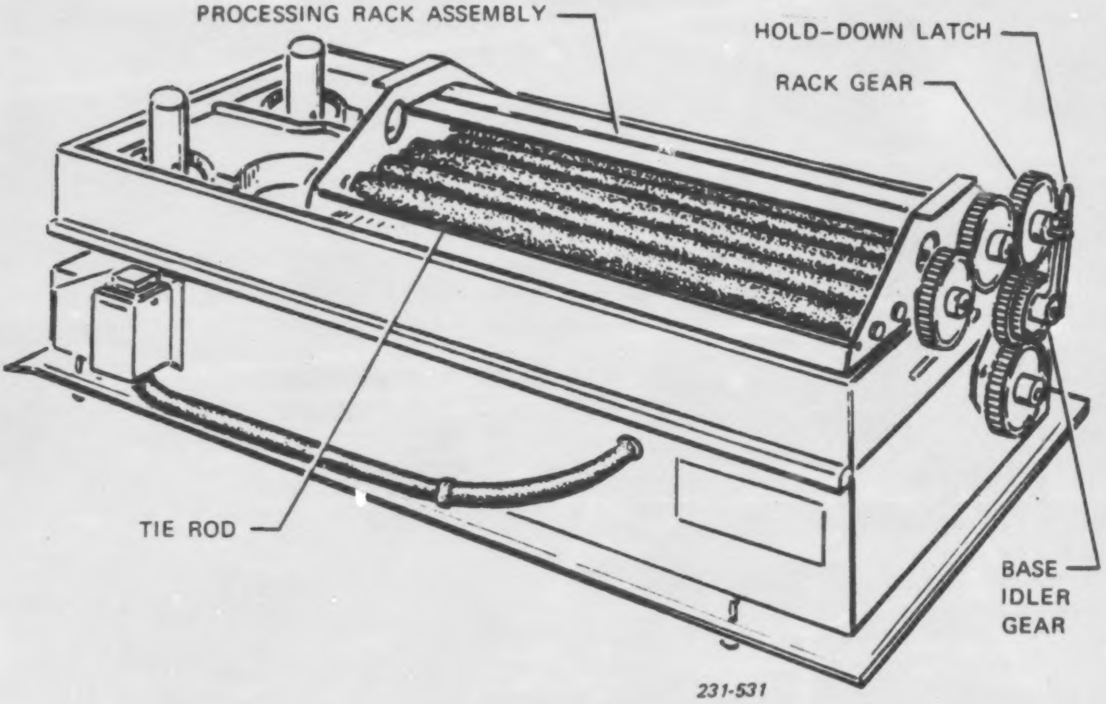

Figure 6-4. Rack assembly installed on the processor.

and squarely for optimum transport. You should not insert paper that is less than 5 inches in length.

Replacing chemical supply bottles. To maintain the strength of the activator and the stabilizer, install fresh bottles of solution as indicated in the photographic paper instruction sheet or once each week—whichever occurs first. Drain and clean the processor. Then install fresh solutions as follows:

(1) Remove the chemical supply bottles, feed shelf, and housing assembly.

(2) Press down and hold the drain bellows, shown in figure 6-9, until all the chemicals have drained from the solution tray into the drain bottles.

(3) Unhook the hold-down latch (shown in fig. 6-4). Raise the left side of the solution tray. While holding a towel or large sponge under both drain bellows, lift the tray and processing rack assembly as a unit and carry it to a large sink.

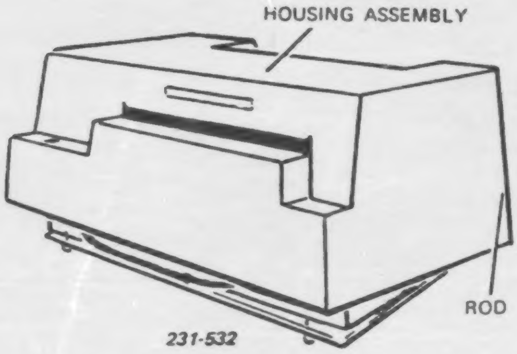

Figure 6-5. Housing assembly of the processor.

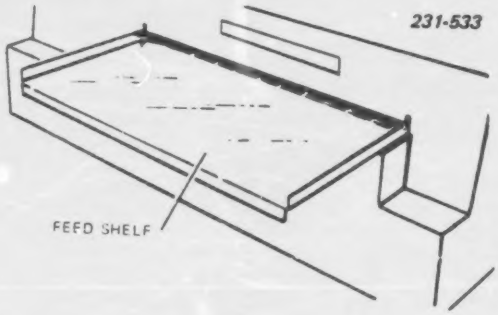

Figure 6-6. Feed shelf of the processor.

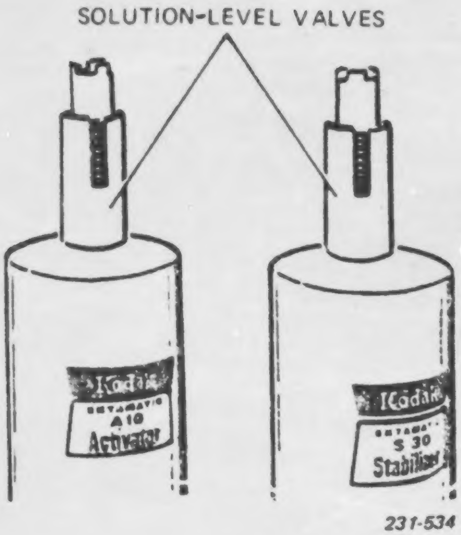

Figure 6-7. Solution-level valves on chemical supply bottles.

(4) Take out the processing rack assembly, and wash the track and chemical tray with fresh water. Use a soft brush to remove stubborn residue from gears, rollers, shafts, etc. Drain water from all parts. Be sure *not* to soak the rack assembly overnight. Place the rack assembly on a flat surface in order to avoid damaging the components.

(5) Take the two drain bottles from their storage mounts and securely cap them, as shown in figure 6-10. Remove the drain bottles and flush each solution down the drain, one at a time. Flush thoroughly with water. If the two solutions are mixed, strong ammonia fumes will result.

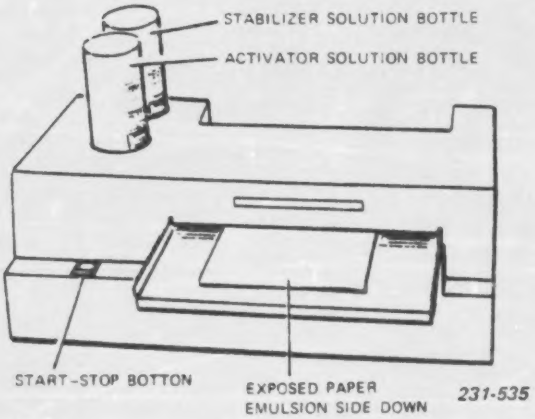

Figure 6-8. Processor in operation.

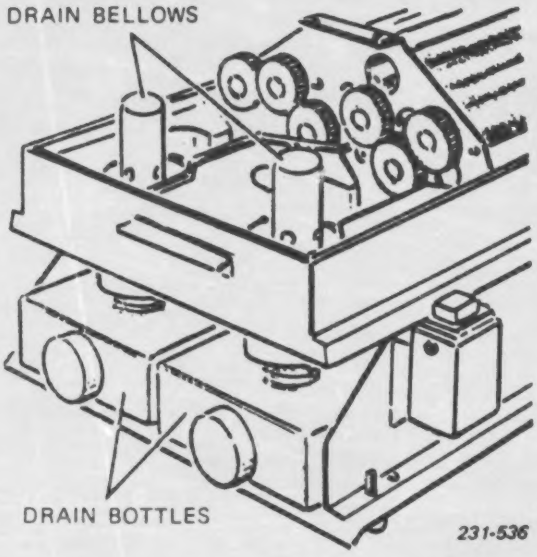

Figure 6-9. Drain bellows and drain bottles of the processor.

CAUTION: The activator causes eye burns. Prolonged or repeated contact with the skin may cause irritation. If activator is splashed in the eyes, flush eyes immediately with plenty of water and get medical attention.

Shut-down procedures. To shut down the processor overnight, simply turn off the processor drive. When starting up the processor the next day, run the drive for approximately 5 minutes before processing the first print. For prolonged shut-down or over the weekend,

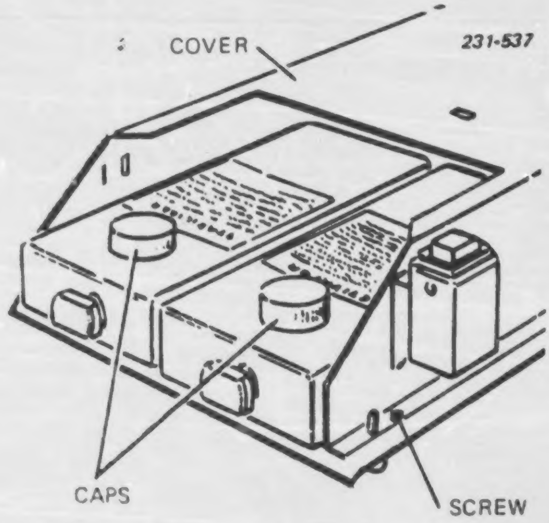

Figure 6-10. Drain bottles ready for removal.

follow the procedures we just explained for "replacing chemical supply bottles."

Maintenance and housekeeping. The following maintenance and housekeeping steps must be accomplished as indicated if your machine is to operate efficiently.

a. Daily. Keep the processor clean and free of chemical splashes by removing any splashes or spills with a damp sponge as they occur.

b. Weekly. Wipe the outer base surfaces with a damp sponge before installing chemical supply bottles. If the processor should accidentally be moved, causing the chemicals to spill, remove the bottles, feed shelf, and housing assembly. Drain the solution trays, and remove the rack assembly tray and drain bottles. Remove the eight screws. Unscrew the leveling feet and slide the cover approximately 4 inches toward the motor end of the processor; then lift the cover from the base plate. Clean all surfaces of the processor with a damp sponge. Reassemble and level the processor.

Exercises (453):

Complete the following statements on stabilization processing.

1. Ektamatic SC paper is a ______-contrast paper that is impregnated with ______.

2. Ektamatic paper can be processed in any ______ print developer.

3. When printing with Ektamatic paper, you use a Wratten ______ safelight.

4. The ______ solution makes the image semipermanent.

5. The ______ solution brings out the image.

6. To have a permanent image, you have to ______ the print.

7. A ______ finish is normally possible only when you are using ordinary print-drying equipment.

8. The Ektamatic 214K can handle paper up to ______ inches in width.

9. For electrical safety, it is important that the Ektamatic be properly ______.

10. The black solution-level valve is used with the ______ solution.

11. You should not insert paper that is less than ______ inches in length.

12. Paper is fed into the Ektamatic emulsion side ______.

13. If the two processing solutions are mixed, ______ fumes will result.

14. The inside of the processor should be cleaned ______.

CHAPTER 7

Print Finishing Techniques

THE FINISHING of prints includes the handling given to the prints from the time they are removed from the fixing bath until they are ready for sorting. In this chapter we shall discuss print washing and washers, drying and dryers, toning, mounting, spotting, and protective finishes. A thorough knowledge of finishing techniques is necessary if you are to turn out high-quality prints that meet mission requirements.

7-1. Washing Prints

Washing is an important step to insure a permanent image. It should never be done in a haphazard manner. You must, therefore, learn proper washing techniques and then apply them in your work. This section will discuss basic principles of washing prints and the use of mechanical washers.

454. State principles and describe procedures related to print washing.

The purpose of washing prints is to remove the residual chemicals that remain in the emulsion base of the paper after development and fixation. Washing dissolves and dilutes the soluble products and eliminates them with the disposal of the wash water. Thorough washing of prints is as necessary as thorough washing of negatives. If processing chemicals remain in the paper, they will discolor and ruin the print. Although chemicals diffuse from both the base and the emulsion of prints during washing, it is necessary to wash prints longer than the time required for negatives because the fibers and baryta coating of the paper absorb the chemicals. (An exception is resin-coated paper, which can be washed in 4 minutes because it does not absorb chemicals at the same rate as other papers.)

Washing Factors. The length of washing time is dependent upon a number of factors. You should consider the following:

a. Proper fixing. Using partially exhausted fixing baths that require longer than normal fixing times will require longer than normal washing times.

b. Temperature of the Water. The higher the water temperature, the faster the chemicals are diffused. Therefore, you get faster washing times at 75° F than at 65° F. (Very high temperatures will damage the emulsion.)

c. Type and weight of the paper. Whether the paper is resin-coated or not affects the washing rate. Resin-coated papers do not absorb the chemicals as do the normal kinds and therefore wash faster. The weight of the paper is significant. Double-weight paper, which is thick and therefore absorbs more chemicals, takes about twice as long as single-weight paper.

d. Method of washing. Whether you are using trays or mechanical washers will significantly affect the water exchange rate and hence the washing times. Mechanical washers, in fact, are a necessity for high-volume washing.

e. Rate of water exchange. The number of complete changes of water to insure that the contaminated water is being completely drained away is important. One change every 5 minutes is recommended to insure proper washing.

f. Amount of agitation. Agitation is essential to insure the free flow of water around each print. The prints must be rotated by hand or tumbled by mechanical means so that each print is adequately washed.

g. Use of a hypo clearing agent. The rinsing of prints in a hypo clearing agent for 3 to 5 minutes prior to washing can significantly reduce washing times. There are a number of commercially made hypo eliminators, and formulas are also given in the Photo Lab Index. Using these solutions according to directions can save you much time.

Washing By Trays. Although most washing is done by mechanical washers (discussed later in this section), small groups of prints may be washed in trays. Two deep trays should be used. The size of the trays selected is determined by the size and number of prints to be washed. Both trays should be filled with water. All prints are then placed emulsion up in one tray. The prints should be separated, agitated, and then transferred one at a time to the other tray. The first tray is then emptied and refilled with fresh water, and the procedure is repeated until the wash is completed. The prints should be agitated by rotation at least two or three times in each change of water and the water changed at 5-minute intervals until about six changes have been given for single-weight prints. Double-weight prints should be given from eight to ten changes.

A second method of washing prints in a tray involves the use of a tray siphon. The siphon directs fresh water into the top of the tray and at the same time removes the chemically contaminated water from the bottom of the tray. The tray siphon method of washing is quite efficient.

Exercises (454):

1. List seven factors that determine print washing times.

2. If a print is not properly washed, what will happen to the image with the passage of time?

3. How often does the water have to be changed when you wash by tray?

4. What is the advantage of washing at 75° F?

5. Why does it take longer to wash double-weight prints than single-weight ones?

455. Identify true or false statements related to the operation and use of print washers.

Mechanical Washer. A convenient method of washing large numbers of small- and medium-size prints is by the use of a mechanical washer. The majority of your print washing may be carried out by using this item of print equipment. Average washing time for non-resin-coated, single-weight prints is less than 30 minutes; double-weights take about 45 minutes to an hour. A mechanical washer sprays fresh water into a rotating drum and at the same time drains off the contaminated water. The rotation of the drum, together with the spray of the water, gives constant agitation to the prints. In mechanical washers, the water is completely changed every few minutes.

Pakolux. A typical mechanical print washer is the Pakolux shown in figure 7-1. The machine washes large numbers of small photographic prints quickly and efficiently. It washes approximately 100 double-weight 8 x 10s in 45 minutes.

To operate the Pakolux, you should follow these instructions:

(1) Close the drain valve so that the tank can be filled.

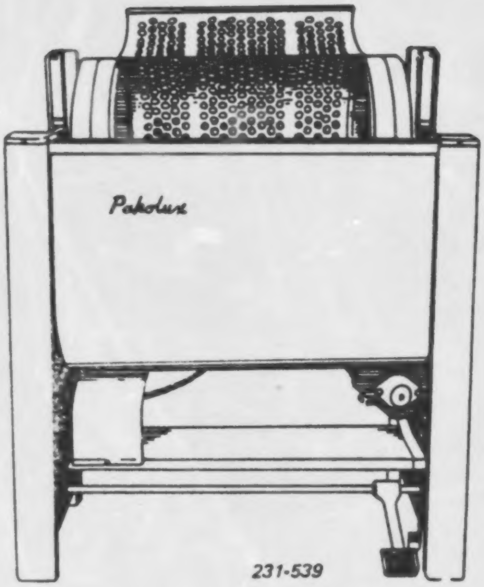

Figure 7-1. Pakolux print washer.

(2) Open the water shut-off valve and allow the tank to fill to the overflow level. By setting the shut-off valve from one-half to three-quarters open, you can maintain a continuous flow of fresh water.

(3) Raise the drum by stepping on the foot pedal and depressing it far enough to engage the pedal lock. Manually rotate the drum until the door in the cage is rotated to the top where the index pins on the lift channels hold the drum in place. Release the locks and open the door.

(4) Place the prints in the drum one by one so that they do not stick together. Close and lock the door. To lower the drum into the tank, push down the foot pedal to release the pedal lock. Allow the pedal to rise slowly. Apply power to the motor by turning on the electrical switch.

(5) When the washing is completed, turn off the power. Slowly raise the drum and lock it in position with the foot pedal. After the drum is rotated in the index position, open the door. Place the prints on the door for a short period to drain off excess moisture.

(6) When all prints have been removed from the washer, close the shut-off valve and open the tank drain valve. When the water has drained out, dry the washer with a clean dry cloth.

Remember to consult the applicable technical order prior to and during operation.

Exercises (455):

Indicate whether each of the following statements regarding machine washing of prints is true or false.

T F 1. Mechanical washers are better able to wash a number of prints than a tray washer.

T F 2. Mechanical washers use the principle of aeration to provide adequate print agitation.

T F 3. When the Pakolux washer is in operation, both the shut-off valve and drain valve should be fully open.

T F 4. The vertical position of the Pakolux drum is controlled by a foot pedal.

T F 5. To fill the tank of the Pakolux, the drain valve must be opened.

7-2. Print Drying

The process of print drying is not the simple, uncomplicated task that it appears to be. It involves a combination of variables, most of which can be satisfactorily controlled. In this section we shall discuss basic drying principles and the operation of mechanical dryers.

456. Complete statements relating to the principles and problems of print drying.

Print Drying Principles. The basic principles of drying paper are similar to those of drying film, which we discussed earlier. The main difference between drying film and drying paper is that the paper backing contains a great deal more moisture than the transparent backing of film does. When you are drying transparent materials, your main concern is the removal of moisture from the emulsion. When drying papers, you are still concerned with removing the moisture from the emulsion, but you are also concerned with removing the large amount of moisture from the paper backing. Often you will find that removal of the water from the paper is a greater problem than the removal of the water from the thin emulsion.

Common Problems Encountered in Print Drying. Some of the problems encountered in print drying are tied directly to specific drying methods, but other problems are common to all print drying. Let us discuss some of the common print drying problems.

Curl. As a print dries, the gelatin shrinks. The more it shrinks, the greater the tendency for curling. The curl is actually caused by the gelatin shrinking more than the paper backing. The most effective method of preventing curl is to dry the print in either an absolutely flat position or a position that causes the emulsion to be stretched; that is, in a position that is reverse to the curl inherent in the paper. If the print is allowed to dry in this position, the tendency to curl is minimized.

In extremely dry climates, you may need to use some additional treatment to prevent the loss of residual moisture for the gelatin. Special flattening solutions are available and help the gelatin to retain its moisture content. These solutions can be purchased from commercial sources. One such solution can be made up of diluted glycerin (a 10-percent solution). If you soak the prints for sufficient time to allow the flattening solution to thoroughly saturate both the emulsion and the paper before you dry the prints, you can keep curling at a minimum.

Shrinkage. The problem of shrinkage is not important for ordinary prints, but when the prints must be used for taking measurements or for assembling controlled mosaics (e.g., maps), shrinkage becomes very serious. Print shrinkage is caused by gelatin contraction and/or paper contraction. The contraction makes the print surface occupy less area than it did at the time it was exposed. Dimensional accuracy can best be achieved by drying the prints slowly and by not subjecting them to any stress before, during, or following the drying process. When available, special dimensionally stable papers should be used.

Cracks. If the emulsion of a print contains cracks, it very often indicates that there has been rough handling of the material. The improper handling may have taken place before exposure, during processing, during drying, or subsequent to drying. If the emulsion of the paper contains the right amount of moisture, it can take a great deal of flexing without cracking. However, if the moisture content drops below normal, the gelatin becomes quite brittle and may crack when it is bent. Excessive hardening of the emulsion and drying at too high a temperature may cause the gelatin to crack more easily. Cracks can result when a print straightener, which bends the print in a reverse curl around a roller, is set to bend the material too sharply.

Change in tone (plumming). When photographic papers are dried by heating, they may change tone. They tend to change toward a colder, more purple color. The effect is dependent upon the amount of heat used, the nature of the sensitized materials, and the tone of the image prior to drying. To prevent plumming, your prints can be soaked in an antiplumming solution prior to drying.

Changes in the appearance of the print surface. When matte and semimatte papers are dried by heat, the surfaces sometimes have a higher sheen than if they are dried naturally. Starch grains are included in the emulsion to provide matting. The rising temperature of the paper causes these grains to burst. While this effect may improve the appearance of some semimatte papers, it is normally considered detrimental for prints on most matte papers.

NOTE: You will probably find that the new resin-coated printing papers are free from many of the print drying problems we have discussed.

Exercises (456):

Complete the following statements related to the principles and problems of print drying.

1. Drying prints takes longer than drying film because prints have a ______ ______.

2. When the gelatin of the paper shrinks faster than the paper, the resulting print will have ______.

3. A ______ solution is used in dry climates to help the gelatin retain moisture.

4. If the emulsion becomes too dry, the paper is likely to ______ when bent.

5. Shrinkage is a serious problem in prints being used to make ______.

6. ______ is a change in the print tone, usually resulting from drying with heat.

457. Complete statements regarding the operation of print dryers.

You will dry the majority of your prints by using mechanical dryers. Therefore, we shall cover the operation of a typical belt dryer suitable for all your conventional print-drying needs. You should note that when you are printing with resin-coated paper, the prints should be air dried or you should use the new type of dryers designed for resin-coated paper.

Belt Dryers. The majority of prints are dried on the motor-driven, belt-type dryer. A belt dryer consists of a drum, over which a wide, endless cloth belt or apron travels. The drum is motor-driven and is usually heated by electricity. The drying rate for prints is regulated by the temperature of the drum and the speed at which the drum rotates. The drum temperature is controlled by a thermostat, while the drum rotation speed is regulated with a variable-speed motor control and a speed reduction system. The prints are held in contact with the drum by means of the belt and are dried during the revolutions of the drum.

The Pakonomy Print Dryer, Model 26W. The Pakonomy Print Dryer, shown in figure 7-2, is typical of the print dryers found in base laboratories. Let us discuss its operation as an example of dryer operation.

General procedure. To start the dryer, turn on the drive and heater switches. When the dryer is up to the proper operating temperature, prints may be placed on the apron for drying. It is best to run a few trial prints first to establish a suitable setting for production prints. Glossy prints are placed on the apron emulsion side up; matte prints, emulsion side down.

A pilot light is provided to indicate when the heater is operating. This light goes out when the heater attains the desired temperature setting. Two thermostats are provided: a control thermostat for manual setting of the required operating temperature, and a safety thermostat inside the heater unit, which prevents damage in the event of the failure of the control thermostat. The safety thermostat is preset at the factory at approximately 200° F, and no further adjustment is required.

For normal operation, set the control thermostat to 190° F for the initial run. Subsequent experience will suggest variations, in conjunction with apron speed, to secure optimum performance under variables of paper weight and humidity.

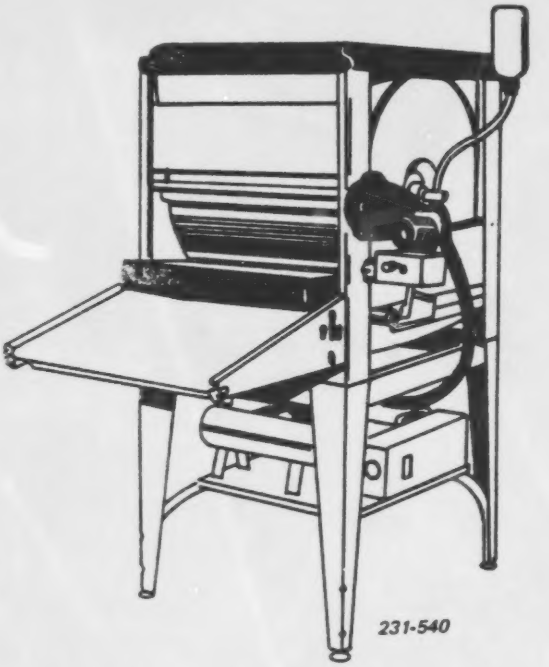

Figure 7-2. Pakonomy print dryer.

The water circulating unit, containing the heater, is provided with an ON-OFF switch and a thermostatic temperature control. The motor drive unit has a similar ON-OFF switch and a rheostat speed control.

With the heater switch ON, the heating elements are on until the drum temperature reaches the level set by the control dial. The control thermostat then automatically turns the elements on and off to maintain the required temperature.

Apron tracking adjustment. Before starting up the dryer the first time, it is advisable to check out the apron tracking adjustment. Insure that the dryer is standing square and level. Then proceed as follows:

(1) Turn on the drive motor switch.

(2) Set the collars on the apron guide shaft to allow a 1/4-inch clearance for each edge of the apron.

(3) When running, the apron will slowly drift away from the tight side. Correct this drift by turning the adjusting screw on the right table arm.

(4) When the apron appears to be centered, run the dryer for an hour to see whether further fine adjustment is needed.

(5) Should the squeegee roller rub on the lever bracket, you can remedy the problem by compressing the collars on the ends of the roller to secure the necessary running clearance. Avoid excessive compression, as this may cause a hump in the roller.

(6) Check the apron rollers for free running. Binding rollers may cause apron friction and generate troublesome static.

Heat and speed settings. Many factors influence the volume of prints dried. These include:

a. Type and brand of sensitized material to be dried.
b. How well the prints are processed.
c. Room temperature and humidity.
d. Maximum practical drying temperature for specific print material.
e. Draining and handling of prints prior to drying.
f. Your operating procedures and cleanliness, especially of the apron.

Adjust the heat and speed settings so that prints drop from the drum as they emerge from the apron with no evidence of dull spots or fleck marks. As a guideline, the following speeds are recommended (speeds are set by the rheostat control on the front of the drive unit):

a. Black-and-white single-weight, glossy—30-36 in/min.
b. Black-and-white double-weight, matte—20-24 in/min.

Do not attempt to use excessive speeds; otherwise, not all prints will dry adequately. Strive to maintain constant speed and temperature settings. Normally, once a suitable setting is found, it is necessary to change speed only if prints of a different weight or type are to be run.

If a print sizzles when first set against the drum, the heat setting is too high. Turn back the thermostat 5° at a time until prints no longer sizzle.

Stopping the dryer. To stop the dryer, first turn off the heater. Run the dryer for at least 5 minutes, and then turn off the drive motor. A badly scorched apron may result if the motor is switched off too soon. NOTE: Never turn on the heater unless the drive motor is running.

For best results, always consult the relevant technical order for the dryer that you are using.

Exercises (457):

Complete the following statements related to belt dryer operation.

1. Matte prints should be placed emulsion side ______ on the apron.

2. Glossy prints should be placed emulsion side ______ on the apron.

3. Glossy prints are dried at a ______ rate than matte prints.

4. The pilot light on the Pakonomy dryer goes out when the heater reaches the ______ ______ ______ .

5. Electrically heated ______ is the Pakonomy Dryer's source of heat.

6. ______ rollers may cause apron friction and generate static electricity.

7. The drive motor should continue to run after the ______ has been turned off.

8. Room ______ and ______ will affect your heat and speed settings.

7-3. Toning Prints

Print toning is a process for changing the overall tone of a black-and-white print by using the appropriate solutions after the print has been normally processed. You may rarely be called upon to tone a print, but it is a useful technique which may enhance a particular print. It may be an ideal technique for preparing a print for display.

458. State principles and describe procedures related to the toning of prints.

Basically, there are two categories of chemical toning. One method is toning by replacement of the silver image with inorganic salts found in sepia toners. Another method is toning with dyes such as methylene blue. Within these two categories are a wide variety of chemical formulas and toning processes. Generally, the processes break down into two broad categories: direct and indirect toning. In direct toning, the print is treated directly in a toning solution. In indirect toning, the image is first bleached and then toned.

It is not possible to discuss each type of toner here as there is such a variety of them, but it is important to consider several general principles that apply to any type of toning that you may try. Consider the following:

a. Select a good print to be toned—one in which toning enhances the image. A bad print (poor composition, poorly processed, etc.) is not improved by toning.

b. Because it is difficult to spot a toned print, make sure that the print is free of dust spots.

c. Carefully select the tone or combination of tones that you are going to use. The tone(s) should enhance the subject matter. For example, blue toners are ideal for snow scenes or water pictures. Brown tones enhance scenics. Red tones may improve a desert picture, etc.

d. Follow directions! This is the key to success in toning. You must follow the directions not only in mixing the toner but in using it. For example, each type of paper is suitable for only certain toners. Too many technicians tend to use any toner they have with the paper they are using and then are disappointed with the result. Furthermore, if you decide to tone your print, it may have had to be processed to a certain density. Many toners tend to add overall density to the print, while some that use a bleaching step tend to reduce overall density.

e. Tone only one or two prints at a time. Constant agitation of the print(s) is important to prevent staining. In addition, the longer the print is in the toning bath, the darker the tone. You, therefore, have to be able to judge the print quite carefully to get the desired result.

f. Washing is important. If a bleaching step is used, the print should be washed for 5 to 15 minutes prior to toning. After toning, the print should again be washed for 5 minutes or more. Prolonged washing after toning, unless called for by the directions, often lightens the toning effect. Do not wash your toned prints in washers that are being used for untoned prints, as the latter may be affected.

g. How the toned print is dried is very important. Air drying a print leaves a bright tone. A cool ferrotyping can cause the tone to darken. A high-heat ferrotype either darkens the tone considerably or causes it to become muddy—depending on the toner that was used.

h. Keep safety in mind. Toners are often made up from very poisonous chemicals. It is therefore safer to use prepared toners than to mix your own from the Photo Lab Index formulas. In either case, it is a good idea to use gloves and a face mask to protect yourself from chemical hazards. The room in which you work should be well-lighted and very well-ventilated, as some toners give off hydrogen sulfide or other fumes. (Along this line, do not tone in a room where sensitized materials are being stored or used, as they may be affected by the toning fumes.)

Toning can add to the overall appearance of your print in a dramatic fashion. Through experimentation and practice, you can add toning to your "bag of tricks."

Exercises (458):

1. What are the two basic methods of toning?
2. Which method of toning requires a bleach step?
3. Why should the print you tone be free of dust spots?
4. What is the primary criterion for selecting a particular color of toner?
5. Why can you tone only a couple of prints at a time?
6. What may happen if you use high heat to dry your toned print?
7. Why should you use a face mask and gloves when you are toning prints?

7-4. Mounting Prints

For exhibition, display, and handling purposes, a print is usually mounted on a stiff board that sets off the picture by a broad border and also protects the edges of the print itself against damage.

459. State principles related to print mounting, and describe procedures and materials that are used to mount prints.

Mounting Principles. In preparing a print for exhibition or display, the objective is to show the print to best advantage. Simplicity is essential in doing this. Any elaborate artwork, such as colored borders or fancy lettering, often detracts from the main point of interest, which, of course, is the print image.

Prints for display purposes are generally mounted on special cardstock to make them stand out from their surroundings. The cardstock is available in various sizes, colors, textures, and weights. While no definite rules can be given, you should use a mount that compliments the print. The mount should be large enough to balance and amply support the picture, while the texture and color should lend themselves to the overall tone. (Before using colored cardstocks, try plain black or dark gray and see how well your work will stand out.)

The placement of the print on the mounting board is of utmost importance. Prints mounted at strange angles or in a corner of the mount are not generally acceptable. The prints should be placedon the board in such a manner that the borders on the sides are equal and, when possible, equal to the top border. For good balance, the bottom border should be about one-third wider than the top and sides. See figure 7-3 for the steps you can follow in placing your print.

Adhesives. The adhesives used for mounting prints are of two types: wet or dry. The liquid adhesives generally used are photo paste, glue, gum arabic, rubber cement, or the new types of pressurized spray fixatives. When you are using these wet adhesives, it is almost impossible to prevent some staining or

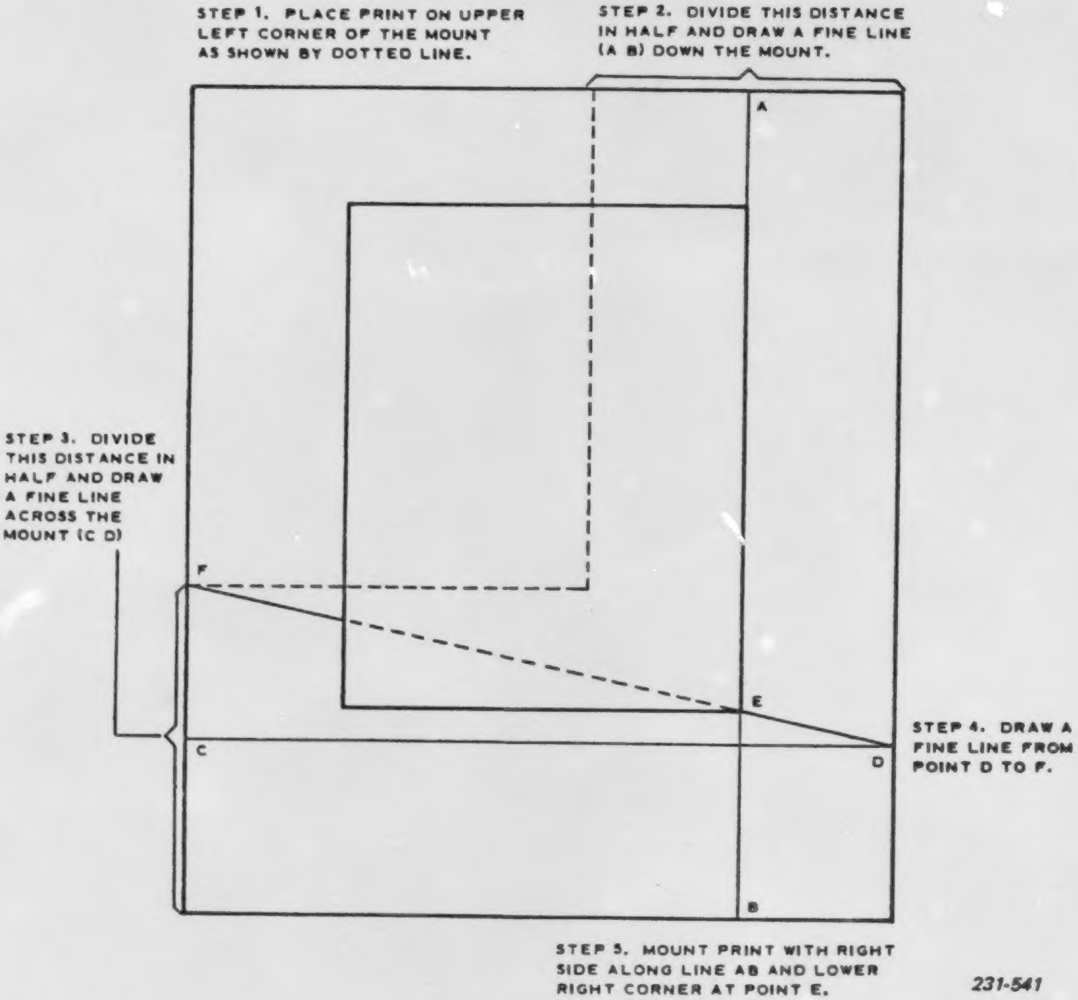
STEP 1. PLACE PRINT ON UPPER LEFT CORNER OF THE MOUNT AS SHOWN BY DOTTED LINE.
STEP 2. DIVIDE THIS DISTANCE IN HALF AND DRAW A FINE LINE (A B) DOWN THE MOUNT.
A
STEP 3. DIVIDE THIS DISTANCE IN HALF AND DRAW A FINE LINE ACROSS THE MOUNT (C D)
F
E
C
D
STEP 4. DRAW A FINE LINE FROM POINT D TO F.
B
STEP 5. MOUNT PRINT WITH RIGHT SIDE ALONG LINE AB AND LOWER RIGHT CORNER AT POINT E.
231-541

Figure 7-3. Positioning a print on a mount.

smearing of the mounting board around the edges of the print. Furthermore, often these glues dry out and the print may loosen and peel off the amount. Therefore, you should use a wet mount only for temporary displays.

Dry mounting is therefore preferred by the careful worker. For a temporary dry mount, you can use double-sided self-adhesive tape. A length of this may be applied to the top edge of the print, or shorter pieces to the four corners. The protective backing of the tape is then stripped off, and the print placed in position on the mount.

For a permanent bond, you can use pressure-sensitive adhesive sheets that require no additional equipment or heat. To use this material, you simply peel off one side of the protective sheets and apply it to the print. Then peel off the protective sheet on the other side of the material and mount the print in place.

The traditional method of dry mounting prints is done by using dry-mounting tissue, a tissue paper coated on both sides with a shellac type of adhesive. The tissue is dry, thin, not sticky, and very easy to handle. Furthermore, it is odorless and chemically inert so that it will not stain a print. Being moisture-proof, it will not wrinkle a print. It is well suited for either double-weight or single-weight prints; and it gives a strong, flexible, and very permenent bond between print and mount. Because the dry mounting process is clean, simple, and efficient, it is the method you will most likely be using in your work. (Dry mounting procedures will be discussed further when we describe the operation of a dry mounting press.)

Exercises (459):

1. What should be your basic concern in selecting the cardstock for mounting your prints?

2. List the five steps to follow when you are positioning a print on a mounting board.

3. What are disadvantages of using a wet mount?

4. What are the primary advantages of dry mounting?

460. Explain procedures related to the operation of a dry mounting press and the process of dry mounting.

Dry Mounting Press. The dry mounting press is an efficient and simple implement for providing attractively mounted photographic prints. Heat is used to fuse the dry mounting tissue between the print and the mounting surface.

Figure 7-4 shows a Type A-2 dry mounting press, which is typical of the kind available in many labs. With this type of press, both the heat and pressure that are required for mounting are provided. For dry mounting black-and-white prints, the press temperature should be set at approximately 235° F. For extra-heavy material, set the press at approximately 275° F. (For resin-coated paper, consult your instruction sheet for proper dry mounting procedures.) This type of press is equipped with indicator lights. A green light glows when the set temperature has been reached. A red light flashes "on" and "off" approximately once every second when the press is closed and provides a means for timing. Check with the applicable technical order or manufacturer's instructions for the operating procedures for your particular unit.

Mounting Steps. The dry mounting process is easy and requires few operational steps. Before doing any actual mounting, prepare the press and dry the cover sheet used to protect the print in the press. A piece of heavy paper, a medium-weight piece of cardboard with a smooth finish, or a photographic blotter works well as a cover sheet. Place the cover sheet on the pad and bring the heated platen into contact with it. Allow the platen to remain down for 1 or 2 minutes to remove all traces of moisture from the cover sheet. Follow this procedure whenever there is a possibility that the cover sheet has absorbed moisture from the air.

Place the untrimmed print face down on a table and put a piece of dry mounting tissue, slightly larger than the print, on top of it. Tack the dry mounting tissue to the print by drawing the beveled edge of the tacking iron (shown in fig. 7-5) across the tissue at several points. With the mounting tissue thus secured to the print, turn the print face up and trim it to its final size, trimming both print and tissue simultaneously. (Watch your fingers when you are trimming!)

Holding the trimmed print in the desired position on the board, tack the print to the board in at least two places. This practice will insure that the print will not move on the board when you are using the press.

Place the print and board on the pad in the press so that the print face is up. Cover the print and mount with the dry cover sheet. Apply pressure and heat by lowering the heated platen and locking it in the down position. After 10 to 20 seconds, release the pressure and remove the print. To test for permanent adhesion between the print and mount, allow the print to cool and then bend the mount backward away from the print. If the print does not adhere to the mount, a further application of heat is necessary.

The amount of heat applied to a print is important. Insufficient heat does not adequately fuse the adhesive to the print and to the mount, and the print may peel away from the mount. Too much heat melts the adhesive and allows the paper of the print and the paper of the mount to absorb it. As a result, the bonding between the print and tissue and between the mount and tissue is not good enough to hold the print.

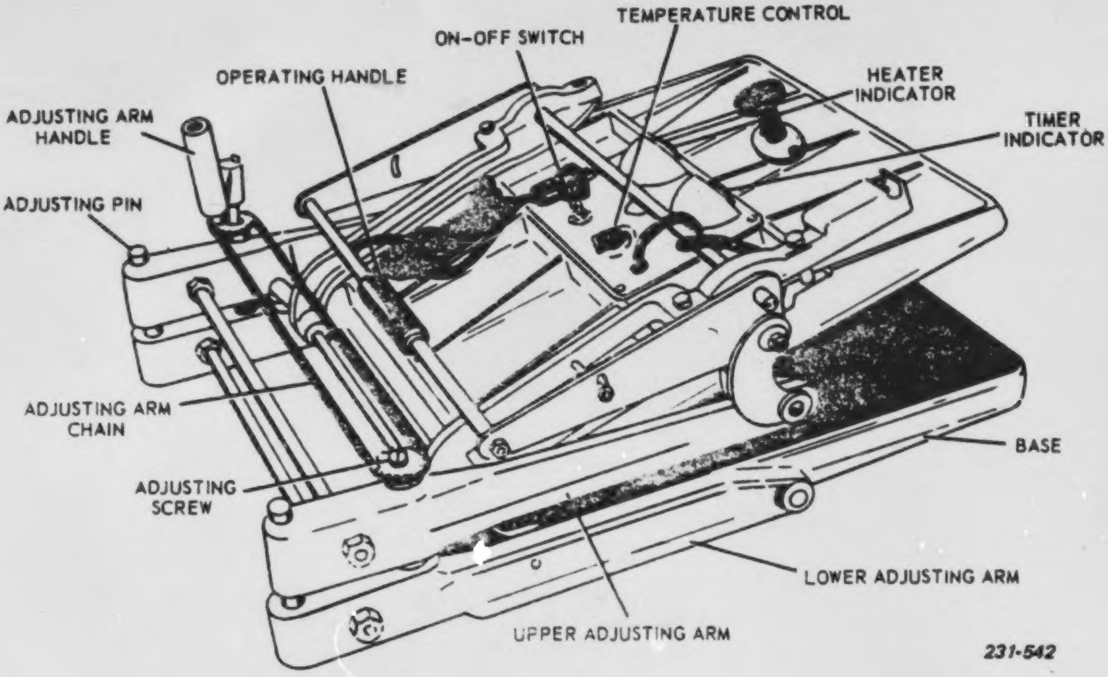

Figure 7-4. Dry mounting press.

Since the mounting time varies according to the conditions and materials, you will need to experiment to achieve ideal bonding.

To mount prints larger than the platen, make several impressions by moving the print so that each portion receives an equal application of heat and pressure.

NOTE: Remember proper safety precautions when you mount. Tacking irons and presses generate high temperatures, which can cause serious burns. Be careful when you use these tools and do not leave them unattended. When you are finished, unplug the equipment and leave a "HOT" sign to warn your fellow workers of possible danger. You will also be using paper trimmers. Remember to leave the trimmer properly latched when you are finished.

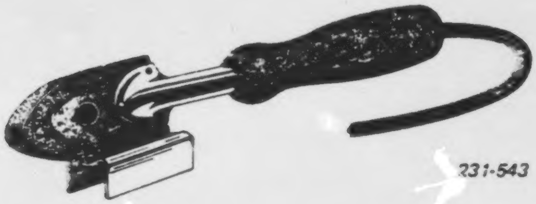

Figure 7-5. Tacking iron on stand.

Exercises (460):

1. What is indicated when the green light on the A-2 dry mounting press glows?

2. What temperature is used for mounting single-weight black-and-white prints?

3. Describe how to prepare a print for dry mounting.

4. Why is it important to use the right amount of heat when you dry mount?

7-5. Spotting Prints

Prints are spotted to eliminate white or gray marks caused by dust, lint, and other similar particles that may have adhered to the negative. Black spots caused by pinholes may also be eliminated. All print surfaces may be spotted. Spotting is necessary to some extent in the majority of prints. Spotting is also performed for the purpose of correcting or toning down certain areas, such as highlights, which appear too bright in a print and which would be difficult to remove from the negative by etching.

In this section we shall cover the basic tools, materials, and techniques used in spotting prints.

461. Complete statements on the tools, materials, and techniques used in spotting prints.

Tools. To do print spotting, it is a good idea to have a clean, well-lighted working space. Light should come from the left (from the right if you are left-handed), or from behind you. Light coming from above or from in front of you causes disturbing reflections on the print. You should have a work bench or a drafting table to work on. Work only with completely processed unmounted prints. It is also a good idea to have a vareity of tools at close hand. Following is a discussion of the major tools and supplies you should have available.

Spotting colors. There are a variety of spotting dyes or water colors, which are either liquid or cakes. These can be mixed and diluted to achieve tones that match the spot to the surrounding areas.

Small water glass. To mix the colors, you need a small glass to hold your water.

Brushes. A good selection of sable brushes is needed to supply the spotting colors.

Photo blotters. Good photo blotters are helpful to wipe up any access moisture on the prints.

White paper. White paper is used to shape the point on your brush when it is loaded with color. It also provides a good check to see that the color is exactly what you want.

Lead and carbon pencils and crayons. A good selection of pencils of different degrees of hardness is essential. Carbon pencils are useful for spotting matte prints. Artist-type crayons can also be used for spotting.

Sandpaper. Sandpaper is helpful in keeping your pencils sharp.

Etching knives. An etching knife can be used to cut away or tone down dark spots.

Retouching Techniques. Retouching takes practice and patience to achieve. After doing it for several hours, you will want to correct the cause of the spots rather than master the cure.

Spotting with water colors or dyes. Water colors or dyes can be applied to any type of surface. With water colors, the technique is to moisten the brush and stroke it half dry on a piece of white paper. Then take up the color from the cake of dry water color, and turn the brush on a piece of white paper. This technique helps get a fine point and at the same time indicates the strength of the color. Then just touch the spot on the print with the tip of the brush. Start with the darker areas first and then work to the lighter ones.

Retouching dyes, unlike water colors, are solutions. The dye should be diluted in the brush while the brush is semidry. Apply the dye repeatedly to the spot until the latter disappears into its surroundings.

Black spots caused by pinholes can be corrected with white dyes, which then can be blended to cover over the spot. (The easiest solution to pinholes is to opaque the negative and then retouch the white spot on the print.)

The key to the use of water colors or dyes is the matching and blending of the color to match the surrounding area. Also, when you are spotting glossy prints, make sure that you use dyes specifically meant for glossy finishes; otherwise, the spotted area will look dull in comparison ot the surrounding area.

Spotting with lead and carbon pencils and with crayons. The use of pencils or crayons may be suitable for covering over a few light spots. If you are retouching glossy prints, you first must use a retouching fluid to provide a rough surface for the lead to hold. Unfortunately, the use of retouching fluid leaves a dull spot, which may detract more from the print than the spot that is being retouched. Papers with matte surfaces accept lead and crayon. A couple of warnings are in order. Pencil lead tends to leave a bright sheen that stands out. The sheen can be dulled by rubbing it with your fingers. Another problem with lead is that there is a tendency for it to smear or to rub off with handling.

Etching. The use of an etching knife to lighten dark spots takes quite a bit of skill. Once the dark spot is removed, it can be spotted with dyes or pencils as the case may dictate. Remember that with glossy prints you will remove the gloss, causing a dull spot.

Exercises (461):

Complete the following statements on the tools, materials, and techniques used in spotting prints.

1. When doing spotting work, your working light should come over your ______ shoulder if you are right-handed.

2. ______ brushes are used in spotting.

3. Carbon pencils are mainly used to spot ______ prints.

4. Pinholes are first corrected with ______ dye.

5. When spotting a glossy print, you need ______ dyes or else the spot will look ______ .

6. Materials that can be used to spot colors on any type of surface are ______ and ______ .

7-6. Protective Finishes

By now you have spent several hours of work producing a top-quality print. To protect your investment against scratches and abrasions, you should use a protective coating.

462. Describe the purpose of using a protective finish and explain how a spray finish should be used.

There are a variety of commercial lacquer-type sprays, which can be applied to any type of print. These sprays, besides providing protection, can also be used to impart a matte or glossy finish to the print. In addition to the sprays, you can apply wax with a soft cloth or varnish with a brush.

Since sprays are very common, let's briefly discuss how they are used. First, the spraying should be done in a well-lighted and ventilated room. The room must be very well-ventilated because the spray fumes are toxic. In addition, the room should be free of equipment or materials. Cameras, dryers, printers, lenses, etc., can be ruined by the spray mist. Finally, the spray can should be kept away from the heat, which can cause a can of spray to explode.

To use the spray, shake the can according to directions and then hold the nozzle about a foot from the print. Spray in an even, sweeping motion. It is better to apply two thin coats than one thick one. A thick coat may leave an orange-peel effect. Practice on an extra print before using the spray on your masterpiece.

Exercises 462):

1. What are two reasons for using a spray finish?

2. Briefly describe how to apply spray to a print.

Bibliography

Books

Carroll, John S. (editor). *Photo Lab Index.* New York: Morgan & Morgan, Inc., Latest Edition and Supplements.

Jacobson, C. I., and L. R. Mannleir. *Enlarging.* New York: The Focal Press, 1969.

Lootens, J. Ghislain. *Lootens on Photographic Enlarging and Print Quality,* New York: Amphoto, 1967.

Department of the Air Force Publications

AFM 52-1, *Ground Cameras and Photo Lab Equipment,* 1 November 1972.

NOTE: None of the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you may request one item at a time on a loan basis from the AU Library, Maxwell AFB, AL 36112, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of *AFMs*. TOs, classified publications, and other types of publications are *not* available.

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

400 - 1. Following directions is necessary to insure proper quality and safety.
400 - 2. Water; temperature.
400 - 3. Ingredient; water.
400 - 4. Quick reference; backup source of information.

401 - 1. Mix 25 grams of hydroquinone into 100 cc of water.
401 - 2. Mix one part D-72 with 3 parts of water. All parts must be measured with the same weighing system (e.g., ounces).
401 - 3. 20° C.
401 - 4. 122° F.
401 - 5. 20 percent.

402 - 1. Metric or avoirdupois.
402 - 2. The smaller the quantity to be weighed, the greater must be the accuracy of the balance.
402 - 3. a. Sliding; individual.
b. Paper.
c. Trimming.
d. Left-hand.
e. Right-hand.
402 - 4. That the material is inert to the chemicals that will be measured.
402 - 5. 2.5.

403 - 1. Formula and proprietary.
403 - 2. Packaged chemicals are easy to store, handle, and mix; and they provide consistent quality.
403 - 3. Follow directions.
403 - 4. In a well-lighted and ventilated room.

404 - 1. Bulk chemicals permit you to prepare solutions you rarely use or those which are not available in packaged form. You will therefore be able to meet special mission requirements you would otherwise be unable to meet.
404 - 2. USANSI Photo Grade.
404 - 3. Technical grade chemicals can be used after they have been thoroughly tested and found to be satisfactory.
404 - 4. Bulk chemicals should be stored in dark stoppered bottles or jars that are shelved in a cool, dry place away from sensitized materials. All containers should be properly labeled.
404 - 5. To take advantage of bulk chemicals, you need a properly stocked chemical mix section. An accurate balance, graduates, thermometer, and stirring rods are a few of the basic items that are required.
404 - 6. Acid should always be slowly added to the water. If water is added to an acid, tremendous heat can be generated, boiling and splattering may result, and you may suffer serious burns.

405 - 1. 50.
405 - 2. Valve B.
405 - 3. Air.
405 - 4. Open.
405 - 5. Recirculating.

CHAPTER 2

406 - 1. The purpose of each processing step is as follows:
a. Developer—To reduce the exposed silver halides to black metallic silver, thereby producing a visible image.
b. Rinse—To stop or retard development in order to prevent overdevelopment.
c. Fixing—To make the developed image permanent by dissolving undeveloped silver halides.
d. Wash—To remove all of the chemical concentrations remaining in the film in order to prevent future discoloration.
e. Drying—To make the film hard and durable for handling.

407 - 1. Using film hangers and a tank.
407 - 2. Roll film is normally processed by rolling it up on a reel and then putting the reel into a tank.

408 - 1. To transmit the maximum amount of light that can be used safely without damage to the sensitized materials being handled.
408 - 2. a. (3).
b. (1).
c. (2).
d. (4).
408 - 3. If you use too bright a bulb, it may damage the safelight filter and may fog the materials.

409 - 1. An orderly darkroom is essential for working effectively and safely in total darkness.
409 - 2. A dirty tray will contaminate the solution poured into it, and the result will be poor quality processing.
409 - 3. Presoaking film prevents the sheets from sticking together and promotes even development.
409 - 4. If you don't count the film as you move from step to step, there is a chance you will not give each sheet the same amount of processing.
409 - 5. Gas bells formed on the film surface can cause dark spots because the developer continues to work underneath the bells.
409 - 6. By insuring complete changes of wash water, you will prevent contiminates from settling on the bottom of the wash tray.

410 - 1. You need to agitate pack film in order to prevent it from sticking together.
410 - 2. Pack film is much thinner than regular sheet film. It is, therefore, more difficult to handle and it can be easily scratched.
410 - 3. Tray processing of roll film creates very awkward handling situations. The long roll must be handled from both ends and passed through the solution. There is a great likelihood of scratches and uneven development.

411 - 1. Tank and hanger processing requires less direct handling of the film, makes solutions usable for a longer period of time, and insures more even processing.

411 - 2. A film hanger is simply a channeled frame suspended below a bar. The bar is long enough to reach across the tank and allows the film frame to hang below the surface of the solution. The frame has channels on the bottom and both sides, as well as a hinged channel across its top.
411 - 3. The immersion of the hanger should be done slowly and smoothly in order to prevent splashing and the formation of air bells.
411 - 4. The pattern of agitation is to lift the hangers up, tilt them 90° to the left, and return the hangers to the solution. Then lift them out, tilt them to the right, and return them to the solution.
411 - 5. If wet film is dried in a hanger, drying marks will form along the edges, thereby reducing the usable negative area.
411 - 6. The only difference is that pack film requires a different type of hanger.

412 - 1. The right amount of tension must be applied to make sure that the film feeds into the reel properly. If you use too much tension, the film will overlap; if you don't use enough tension, the film will skip.
412 - 2. By having the tank filled with developer, you will better insure even development.
412 - 3. By using a clip on the free end to act as a weight.

413 - 1. Time; temperature.
413 - 2. Useless.
413 - 3. 68.
413 - 4. Swelling.
413 - 5. Inspection.
413 - 6. Reticulation.

414 - 1. The purpose of agitation is to cause a more rapid exchange of the used solution absorbed into the gelatin and the fresh solution from outside the gelatin.
414 - 2. An underdeveloped negative—a negative that lacks a good tonal scale, detail, and contrast.
414 - 3. By stacking them emulsion side up, in the tray and rotating them from the bottom to the top.
414 - 4. The basic difference is that tray agitation requires continuous agitation whereas tank agitation is intermittent.

415 - 1. a. (4).
b. (1).
c. (5).
d. (2).
e. (3).
415 - 2. a. (4).
b. (3).
c. (5).
d. (1).
e. (2).

416 - 1. The three purposes of a stop bath are to stop or retard development, to prolong the life of the fixing bath, and to prevent stains.
416 - 2. Water and 28 percent acetic acid.
416 - 3. Plain water, acid, and hardening.
416 - 4. The primary purpose of a fixing bath is to make the image permanent by dissolving undeveloped silver halides.
416 - 5. Plain, acid, and acid hardening.
416 - 6. Water, sodium thiosulfate, acetic acid, sodium sulfite, and potassium alum.

417 - 1. A black-and-white positive can be made by contacting the original negative with copy film and then processing the film in the normal manner, following the directions for the specific type of film.
417 - 2. To prevent buckling of the film when the film is subjected to the heat of the projector.

CHAPTER 3

418 - 1. Rapid; warm.
418 - 2. Less.
418 - 3. Higher; less.
418 - 4. 0.005.
418 - 5. Tray.
418 - 6. Tank.

419 - 1. To help prevent uneven drying that could cause water spots.
419 - 2. Prepare a 2-percent solution of wetting agent by following appropriate directions. Then bathe the film in the solution for about 2 minutes. Drain the film and sponge off any excess liquid. The film is then ready to be dried.

420 - 1. Dry, warm, circulating air—air that contains a lower relative percentage of moisture than the gelatin.
420 - 2. In the direction of the dry areas.
420 - 3. A low-himidity environment.
420 - 4. The velocity, temperature, and humidity of the air.
420 - 5. Damage to the emulsion.
420 - 6. By attaching a film clip to the bottom of the film.
420 - 7. Water spots can cause permanent crater-like formations in the emulsion, which will show up in a print.

421 - 1. Clean.
421 - 2. 100.
421 - 3. Drained.

422 - 1. To reduce the density in a particular part of a negative.
422 - 2. a. Large.
b. Etching knife.
c. Easel.
d. One.
e. Light.
f. Retouching.

423 - 1. To eliminate pinholes or small transparent spots in the emulsion.
423 - 2. To cover areas of the negative that you don't want to appear on the print.
423 - 3. a. White.
b. Base.
c. Small hole
d. Opaque.
e. Sodium sulfite.

424 - 1. Acetic acid; 4; 6.
424 - 2. Double.
424 - 3. Salts.
424 - 4. Ammonia.
424 - 5. Pure.

425 - 1. Moisture, strong light, and heat.
425 - 2. Between 40 and 50 percent.
425 - 3. The formation of fungus on the film.
425 - 4. Storage cabinets should be raised so that the lowest shelf or drawer is at least 6 inches off the floor in order to prevent any possible water damage that may be caused by flooding or sprinkler discharge, etc.
425 - 5. To remove dust and reactive gases.
425 - 6. It is a good idea to make a duplicate negative and use that, while filing away the master.

CHAPTER 4

426 - 1. Bromide papers.
426 - 2. Chloride papers.
426 - 3. Chloride papers.
426 - 4. Silver bromide and chlorobromide papers.

427 - 1. 1 - Soft; 3 - Moderately high contrast; 5 - Very-high contrast.
427 - 2. No. 2.
427 - 3. By matching the negative to a certain grade of paper. (Contrast control through development is mainly used with certain monocontrast papers.)

428 - 1. One set of halides is sensitive to blue-violet light, while another set is sensitive to yellow-green light.
428 - 2. A set of appropriate printing filters.

429 - 1. a. Number 2 (or no filter).
b. Number 4.
c. Number 1.
429 - 2. From number 1 (light yellow) to number 4 (dark magenta), with intervals of 1/2.
429 - 3. Because variable-contrast paper is sensitive to green, using this yellow-green filter would cause fogging.

430 - 1. The finish and texture of the paper.
430 - 2. The paper's surface controls the amount of light that is reflected from the print, thereby transmitting or obscuring detail. It is therefore important to match the surface to the type of image you wish to convey.

431 - 1. c.
431 - 2. a.
431 - 3. b.
431 - 4. a.
431 - 5. c.
431 - 6. b.
431 - 7. a.

432 - 1. Edges.
432 - 2. Front.
432 - 3. 8.
432 - 4. Moisture; light; heat; chemical fumes; careless handlling.
432 - 5. 70° F.

CHAPTER 5

433 - 1. Purpose; tone.
433 - 2. Quality; texture.
433 - 3. Test strips.

434 - 1. Platen
434 - 2. Individual lamps.
434 - 3. 9½.
434 - 4. Filter.
434 - 5. Diffusion.

435 - 1. The negative and the paper should be placed emulsion to emulsion, with the negative laid emulsion side up on the contact printer glass.
435 - 2. Examine the paper carefully: the paper will have a slight curl toward the emulsion, and the emulsion side will reflect more light.
435 - 3. The sizes of the images should be the same.
435 - 4. By contact printing strips of roll film negatives or a couple of cut film negatives on an 8 x 10 sheet of paper.

436 - 1. Lens-to-negative.
436 - 2. Diameters.
436 - 3. Dustless; glass-sandwich.
436 - 4. Diagonal.
436 - 5. Smaller.
436 - 6. Condenser.
436 - 7. Diffusion.

437 - 1. 100.
437 - 2. 4 x 5.
437 - 3. Variable-contrast.
437 - 4. Glassless.
437 - 5. Reverse.

438 - 1. Dust and lint will cause the projection light to be diffused, causing white spots to appear on the print. Dust and lint can be brushed, wiped, or blown off. In more difficult cases, the negative may need to be cleaned with alcohol or negative cleaner.
438 - 2. The negative and the paper should face emulsion to emulsion.
438 - 3. The image size is controlled by the distance from the lens and the paper. This can be changed by raising or lowering the printer head. As the distance increases, the image size increases.
438 - 4. Horizontal and vertical.
438 - 5. In projection printing, you have control over the image size, and you can easily change the format. This flexibility is not available in contact printing.

439 - 1. Negative; paper.
439 - 2. Opaque leader material.
439 - 3. The type with a fixed frame and the type with adjustable masking strips.

440 - 1. Test strips are used to calculate printing exposure and to determine the correct paper grade or variable-contrast filter to use.
440 - 2. Test strips are economical because several can be cut from one sheet of print paper. This procedure is far cheaper than making tests on full sheets of paper.
440 - 3. Inspect the highlight areas of the test strip carefully. The highlights should be slightly darker than unexposed paper and have some detail.
440 - 4. Carefully examine the shadow area of the test strip that has the correct highlight exposure. If the shadow area of this test is too light, the paper does not have sufficient contrast. If the shadow area is too dark, the paper has too much contrast.

441 - 1. The purpose of dodging is to reduce density in a particular area of a print.
441 - 2. By turning off individual printing lights.
441- 3. To add density in a local area of a print.
441 - 4. To burn-in during projection printing, you first make your basic overall exposure. You then make your additional exposure, using a piece of cardboard with a hole in it. The hole will pass the light to the area that needs additional exposure while holding back light in those areas that don't need any more.
441 - 5. If you do not move your dodging or burning-in tool during exposure, an outline of the tool will be "printed" on the paper.

442 - 1. Tone is the overall color of the image produced by the paper. Some papers produce a warm tone, while others are much colder.

442 - 2. Print contrast is the difference between the highlights and the shadows of the print image. The greater the difference, the higher the contrast.
442 - 3. The final appearance of the print will depend as much on the type of paper that is selected, the choice of developer, your exposure and contrast control techniques as on the quality of the original image.
442 - 4. The inherent contrast of the negative, the choice of graded paper or variable-contrast filter, and your developer.
442 - 5. Mission requirements are the reason why you are producing the print. The requirements of the mission will influence the choice of paper and your printing techniques. If your product does not meet mission requirements, you have not been successful.

433 - 1. a. 4.
b. 1.
c. 4.
d. 3.
e. 1.
443 - 2. Roll-type filters.

443 - 3. The filters should be clean and in good order. If a filter fades with age, it must be replaced.
443 - 4. Argon lighting is very rich in blue and, therefore, doesn't have the green spectral quality necessary for variable-contrast paper.

444 - 1. The horizon line should be level and should not divide the picture in half.
444 - 2. Live subjects should be looking into the picture, not out of it.
444 - 3. As cropping guides, which you can use to determine the best picture crop.
444 - 4. When you are projection printing and need to have a bigger image size.
444 - 5. The subject. (Tall, thin subjects are best shown vertically, while broad subjects appear better horizontally.)

445 - 1. Small.
445 - 2. Upward.
445 - 3. Small.
445 - 4. Large.
445 - 5. Two.

446 - 1. First you contact the original with a sheet of copy film to produce a positive. With the positive, you can then produce as many duplicate negatives as you need.
446 - 2. In projection printing, you can produce a master that is cropped, dodged, and burned in.
446 - 3. The limited selection of film sizes and more involved processing.

CHAPTER 6

447 - 1. A definite routine results in less waste, is not as tiring, and is also safer.
447 - 2. A temperature of 70° F provides a comfortable working environment and is an aid in maintaining proper solution temperatures.
447 - 3. The two types are a clock and an interval timer. The clock is used to time the processing steps. The interval timer is used to control print exposure.
447 - 4. You need two sets in order to prevent contamination. One is used in the developer and to transfer the print to the stop bath. The second set can handle the print through the remaining steps.
447 - 5. Cleanliness saves time and materials. A common cause of poor-quality darkroom production is a lack of cleanliness.

448 - 1. b., e., g.
448 - 2. That the mixing container is clean and that it is made of material that will not react with the chemicals to be mixed.
448 - 3. Follow the manufacturer's directions.
448 - 4. It is a good idea to wear rubber gloves and a face mask.
448 - 5. Splashing of the solution and the introduction of air into the solution.

449 - 1. Continuous agitation (because the prints are tray processed).
449 - 2. The emulsion should face up in order to prevent air bubbles from forming on the surface.
449 - 3. You need to have your timer start as the sheet is going into the solution. You also need to provide for a 10-second drain time at the end. Thus, if you have a 2-minute processing time, you should continuously agitate for 1 minute and 50 seconds and then drain the print for 10 seconds before putting the print into the stop bath.
449 - 4. Agitate the sheets of paper by rotating them from bottom to top through the stack. As you bring the bottom print up, put it emulsion side down on the top of the stack. The next time you go through the stack, put the prints emulsion side up. Continue this procedure through the development time.

450 - 1. A stop bath that stops development is an aid in accurate development times because development is not continuing beyond the developer solution.
450 - 2. The main advantage is that an aid stop bath reacts chemically with the developer solution remaining on the print. This chemical reaction stops the action of the developer. A water stop bath only dilutes the action of the developer; it does not stop it.
450 - 3. Normally, from 15 to 30 seconds.
450 - 4. To prevent excessive swelling or softening of the emulsion. (This is particularly important when you are processing at high temperatures.)
450 - 5 The advantage of resin-coated paper is that it can be fixed in 2 minutes, a period of time considerably shorter than that necessary for other types of paper.

451 - 1. As the solution temperature rises, the processing time is reduced to achieve the same degree of development. Conversely, as the temperature decreases, the processing time increases to achieve the same degree of development.
451 - 2. Use a thermometer to check the temperatures and a water mixing valve to get the water for mixing the solutions to the right temperature.

452 - 1. A number of oxidation and chemical byproducts are formed as the developer changes the exposed halides to black metallic silver.
452 - 2. Mottle is streaky development. It is caused by a lack of agitation during development of the print. The defect occurs because the diffusion of fresh developer and reaction byproducts from within the emulsion takes the path of convection currents. These currents form random patterns that cause uneven development.
452 - 3. Air bells are tiny bubbles in the developing solution. They can cling to the paper emulsion, causing clear spots to occur on the print because there was not full development.
452 - 4. Tray; prints.

453 - 1. Variable; developer.
453 - 2. Standard.
453 - 3. OC.
453 - 4 Stabilizer.
453 - 5 Activator.
453 - 6. Fix.
453 - 7. Glossy.
453 - 8. 14.
453 - 9. Grounded.
453 - 10. Activator.
453 - 11. 5.
453 - 12. Down.
453 - 13. Ammonia.
453 - 14. Weekly.

CHAPTER 7

454 - 1. The seven factors are (1) the proper fixing of the print, (2) temperature of the water, (3) type and weight of the paper, (4) method of washing, (5) rate of water exchange, (6) amount of agitation, and (7) use of a hypo clearing agent.
454 - 2. It will become discolored.
454 - 3. Every 5 minutes.
454 - 4. The higher the water temperature, the faster the chemicals are diffused. Therefore, if you wash the prints in 75° F water, your washing times will be less than if you used colder water.
454 - 5. Double-weight paper is thicker and absorbs more chemicals. Therefore, it takes longer to wash double-weight paper.

455 - 1. True.
455 - 2. False.
455 - 3. False.
455 - 4. True.
455 - 5. False.

456 - 1. Paper backing.
456 - 2. Curling.
456 - 3. Flattening.
456 - 4. Crack.
456 - 5. Mosaics.
456 - 6. Plumming.

457 - 1. Down.
457 - 2. Up.
457 - 3. Faster.
457 - 4. Desired temperature setting.
457 - 5. Water.
457 - 6. Binding.
457 - 7. Heater.
457 - 8. Temperature; humidity.

458 - 1. Direct and indirect.
458 - 2. The indirect method.
458 - 3. It is difficult to spot a toned print, so you should start with a clean print.
458 - 4. The color of the toner should enhance the print image. For example, a blue tone goes well with subjects we associate with blue, such as water scenes.
458 - 5. You must constantly agitate your prints in the toner for even results. You also need to judge the effect of the toner, for the longer the print is left in the solution, the darker the tone will be.
458 - 6. A high heat may cause the tone to significantly darken or even cause it to become muddy.
458 - 7. Protective equipment is important because many toners give off noxious fumes or can cause other chemical hazards because of their poisonous content.

459 - 1. The cardstock's color, size, texture, and weight should enhance the print image to be mounted.
459 - 2. The five steps are: (1) place the print on the upper left corner of the mount; (2) divide the distance on the right-hand side and draw a fine vertical line down the mount; (3) divide the distance from the bottom of the print to the bottom of the mount in half and draw a fine horizontal line across the mount; (4) draw a fine diagonal line from the bottom left edge of the print to the point where the horizontal line drawn in step 3 ends on the right-hand side of the board; and (5) mount the print with the right side along the vertical line drawn in step 2 and with the lower right corner touching the point formed by the intersection of the line drawn in step 2 and the diagonal line drawn in step 4.
459 - 3. Wet mounting may not produce a permanent mount and may also cause stains and smears.
459 - 4. It is a clean, simple, efficient process that results in a bond that is normally permanent.

460 - 1. That the set temperature has been reached.
460 - 2. 235° F.
460 - 3. Place the untrimmed print face down on a table and put a piece of dry mounting tissue, slightly larger than the print, on top of it. Tack the dry mounting tissue to the print by drawing the beveled edge of the tacking iron across the tissue at several points. With the mounting tissue secure, turn the print face up and trim it to its final size. Then tack the print to the mounting board, and you are ready for the press.
460 - 4. The right amount of heat insures good results. Too little heat and there will not be adequate fusion. Too much heat and the adhesive will be absorbed. In either case, you will not have a permanent bond.

461 - 1. Left.
461 - 2. Sable.
461 - 3. Matte.
461 - 4. White.
461 - 5. Special; dull.
461 - 6. Dyes; water colors.

462 - 1. A spray finish provides a certain amount of protection against scratches and abrasions; it can also impart a particular kind of finish.
462 - 2. Shake the spray can and then hold the nozzle about a foot from the print. Spray in an even sweeping motion.

STOP- **1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.** **2. USE NUMBER 1 OR NUMBER 2 PENCIL.**

23132 03 21

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

PROCESSING AND PRINTING OF BLACK-AND-WHITE MATERIALS

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that numerical sequence on answer sheet alternates across from column to column.
3. Use a medium sharp #1 or #2 black lead pencil for marking answer sheet.
4. Circle the correct answer in this test booklet. After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'TS:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #1 or #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed*. Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (400) In the preparation of photo solutions, the most important thing to remember is to

   a. follow the written directions.
   b. use a stainless steel mixing tank.
   c. always add water to your chemicals.
   d. keep the mixing temperature at 125° F.

2. (401) A 20 percent solution of sodium sulfite would require a mixture of how many grams of sodium sulfite per 100 cc of water?

   a. 10.
   b. 20.
   c. 30.
   d. 40.

3. (401) A 1:2 solution of D-76, is the same as a D-76 solution of

   a. 25 percent.
   b. 33 1/3 percent.
   c. 50 percent.
   d. 66 2/3 percent.

4. (402) What type of balance is used to measure grams?

   a. Avoirdupois.
   b. English.
   c. Metric.
   d. Kati.

5. (402) When using a beam balance, minor inequalities in weights are compensated for by using

   a. the laddle.
   b. paper weights.
   c. the counter balance.
   d. the trimming device.

6. (403) Which of the following is a proprietary formula?

   a. Thiosulfate.
   b. Dektol.
   c. D-23.
   d. D-19.

7. (404) Which of the following indicates the highest standard of chemical purity?

   a. Technical.
   b. Chemically pure.
   c. Primary standard.
   d. National formulary.

8. (405) When mixing chemicals in the A-1 mixer,

   a. valves A and B are open.
   b. valves A and B are closed.
   c. valve A is open and valve B is closed.
   d. valve B is open and valve A is closed.

9. (406) The conversion of the latent image to a visible one takes place in which processing solution?

   a. Wash.
   b. Rinse.
   c. Developer.
   d. Fixing bath.

10. (407) Which of the following types of film is not developed in a tank?

   a. Cut film.
   b. Pack film.
   c. Roll film.
   d. Polaroid.

11. (408) Which safelight filter is used in processing orthochromatic film?

   a. 1.
   b. 1A.
   c. 2.
   d. 3.

12. (409) X-bottom trays are ideally suited for which processing solution?

a. Fixing bath. c. Rinse.
b. Developer. d. Wash.

13. (409) To prevent sheet film from sticking together during tray processing, you should use

a. a theosulfate wash. c. a film stripper.
b. an ammonia bath. d. a presoak.

14. (410) Unlike sheet film, to process roll film in trays, you need to use

a. hangers. c. film clips.
b. a presoak. d. an agitator.

15. (411) Once the sheet film hangers are in the developing solution, strike them sharply against the side of the tank several times to

a. align the hangers.
b. dislodge air bells.
c. dislodge gas bells.
d. confirm that the sheets are secure within their respective hangers.

16. (412) Excessive tension used when loading roll film on a reel will

a. increase the chance for pinholes.
b. cause the film to skip over a groove.
c. overlap the film in one of the grooves.
d. permit the loading of more than one roll on the reel.

17. (413) By having all the processing solutions at the same temperature, you can prevent

a. plumming. c. air bells.
b. gas bells. d. reticulation.

18. (414) In what part of the negative does the developer become more quickly exhausted?

a. Middle tones. c. Shadows.
b. Highlights. d. Base.

19. (414) Roll film tank processing requires what kind of agitation?

a. Intermittent. c. Trubulent.
b. Continuous. d. Air burst.

20. (415) Metol is

a. a slow working reducing agent.
b. a low contrast reducing agent.
c. a high contrast reducing agent.
d. highly sensitive to changes in temperature.

21. (415) The main reason for using an accelerator in the developing solution is to

a. make the solution alkaline. c. make the solution acidic.
b. insure selective reduction. d. prevent oxidation.

22. (415) Borax would be classified as which type of accelerator?

a. Mild.
b. Active.
c. Moderate.
d. High contrast.

23. (415) Which of the following chemicals is commonly used as a restrainer in the developer?

a. Diamine.
b. Chrome alum.
c. Sodium sulfate.
d. Potassium bromide.

24. (416) All fixing baths must contain

a. silver halide solvent.
b. a hardening agent.
c. an accelerator.
d. a buffer.

25. (416) Which chemical is used as a preservative in the fixing bath?

a. Sodium thiosulfate.
b. Sodium bisulfite.
c. Potassium alum.
d. Sodium sulfite.

26. (417) Which of the following film/developer combinations would be best suited in producing a positive from a negative?

a. Tri-X and D-19.
b. Plus-X and DK-50.
c. Kodak 6120 and D-23.
d. High Contrast Copy and D-72.

27. (418) Film washing time is not affected by the

a. chemical composition of the fixing bath.
b. temperature of the wash water.
c. efficiency of the wash system.
d. type of developer used.

28. (418) When washing sheet film in trays, the water should be changed approximately ever 3 minutes for a minimum of how many changes?

a. 3.
b. 5.
c. 10.
d. 20.

29. (419) The use of a wetting solution prior to drying the film helps prevent the formation of

a. water spots.
b. air bells.
c. stains.
d. grain.

30. (420) For drying negatives, the air should be

a. warm, humid, and circulating.
b. warm, dry, and circulating.
c. cold, humid, and still.
d. cold, dry, and still.

31. (421) Prior to putting film in the EL-4 dryer, you should

a. drain the film.
b. use an ammonia bath.
c. put the film in hangers.
d. set the dryer's thermostat at 150° F.

32. (422) The main reason for etching a negative is to

a. add density to the base.
b. add density to the emulsion.
c. remove density from the base.
d. remove density from the emulsion.

33. (423) The purpose of spotting a negative is to

a. eliminate the need for print spotting.
b. eliminate small transparent areas.
c. reduce negative density.
d. reduce printing times.

34. (424) For best archival quality, the stop bath should be maintained between a pH of

a. 2 and 4.
b. 3 and 5.
c. 4 and 6.
d. 5 and 7.

35. (424) To achieve archival quality, you should use

a. a double fixing bath arrangement.
b. a stop bath with a pH of 3.
c. contaminated water.
d. bleach.

36. (425) For proper protection of negatives, the relative humidity of the storage area should be between

a. 30 to 40 percent.
b. 40 to 50 percent.
c. 50 to 60 percent.
d. 60 to 70 percent.

37. (426) The fastest type of graded papers are

a. chlorobromide.
b. chloride.
c. bromide.
d. polyide.

38. (427) Which grade of paper should be used to achieve normal contrast with a normal negative?

a. 1.
b. 2.
c. 3.
d. 4.

39. (427) To achieve a normal print from a very contrasty negative, you would use which grade of paper?

a. 0.
b. 1.
c. 2.
d. 3.

40. (427) Print contrast is best controlled through

a. proper agitation.
b. exposure and development.
c. selection of a particular developer.
d. selection of the proper grade of paper.

41. (428) To achieve high contrast with variable contrast paper, it must be exposed with what color of light?

a. Yellow-green.
b. Blue-violet.
c. Red-yellow.
d. Blue-green.

42. (429) The color of the number 4 Polycontrast filter is

a. dark magenta.
b. yellow.
c. green.
d. red.

43. (429) Printing with variable contrast paper would be done with which kind of safelight?

a. A.
b. 1A.
c. OA.
d. OC.

44. (430) The surface of a print refers to its

a. tint and tone.
b. finish and tone.
c. tint and texture.
d. finish and texture.

45. (431) A matte surface is good for use in

a. obscuring detail.
b. emphasizing grain.
c. emphasizing detail.
d. reproducing the photograph.

46. (432) Which of the following will not normally damage processed prints?

a. Heat.
b. Light.
c. Chemical fumes.
d. Humidity of 40-50 percent.

47. (433) Which of the following is not one of the main points to be considered when matching the negative to the print paper?

a. The quality of the negative.
b. The intended purpose of the picture.
c. Test results of paper and negative combinations.
d. The exposure index for both the negative and the paper.

48. (434) Uniform illumination can be maintained on the EN-22A through the use of

a. masks.
b. plate glass.
c. diffusion glass.
d. incandescent lamps.

49. (435) To produce contact prints, the negative and the paper are laid

a. emulsion to emulsion.
b. emulsion to base.
c. base to emulsion.
d. base to base.

50. (436) The sharpest type of enlargements are produced on

a. condenser-type projection printers.
b. diffusion-type projection printers.
c. continuous contact printers.
d. manual contact printers.

51. (437) When using the EN-52B projection printer, which size lens is normally used for printing 120 film?

a. 50mm.
b. 100mm.
c. 150mm.
d. 250mm.

52. (438) What is the primary reason for making lens-to-negative distance changes when doing projection printing?

a. Insure sharp focus.
b. Correct for distortion.
c. Increase depth of field.
d. Achieve proper enlargement.

53. (439) Which of the following materials would be best suited for making a contact printing mask?

a. Wood.
b. Metal.
c. Black paper.
d. Opaque leader material.

54. (440) When making test strips,

a. each strip should be processed for a different time.
b. they should be produced from each part of the negative.
c. each strip should be made with a different degree of enlargement.
d. all strips should be exposed from the same part of the negative.

55. (441) To dodge during contact printing, you should

a. change filters.
b. use an opaque mask.
c. extend the exposure time.
d. manipulate individual printing lights.

56. (441) Burning-in is used during printing to

a. decrease density.
b. increase density.
c. increase contrast.
d. decrease tonality.

57. (442) To decide on the proper tone and contrast for a particular print, a rule that would not normally be considered is that the

a. tone and the contrast are wholly dependent on the quality of the negative.
b. tone and contrast of the original subject be duplicated.
c. detail be preserved in both the shadows and the highlights.
d. photograph must meet the mission requirements.

58. (443) When using variable contrast filters, which of the following rules is not applicable?

a. The filter will fade with use.
b. The filters must be kept cleaned.
c. It is important that the filter be flat.
d. The same exposure is used in changes from one filter to another.

59. (444) How should a horizon line normally appear in a print?

a. Level.
b. Centered.
c. Diagonally.
d. Vertically.

60. (444) In terms of composition, where should the subject normally be placed in the print?

a. Centered.
b. In an appropriate corner.
c. Looking out of the picture.
d. Slightly left, right, above or below the center.

61. (445) For maximum distortion control, it is necessary to be able to tilt the

a. easel.
b. negative.
c. negative and the easel.
d. negative and the easel on two axes.

62. (446) Negative duplicates are made from

a. a master positive.
b. a master negative.
c. an inter-negative.
d. a master print.

63. (447) For printing purposes, which of the following is not needed in a darkroom?

a. Print tongs.
b. A water mixing valve.
c. A temperature of 80° F.
d. An interval and clock timer.

64. (448) Which of the following should not be done when preparing a print developer?

a. Follow directions.
b. Stir to induce air into the solution.
c. Wear rubber gloves and a face mask when mixing.
d. Use amber stoppered bottles for storage.

65. (448) Which of the following developers is designed for warm-tone papers?

a. Ektaflow Type 1.
b. Versatol.
c. Selectol.
d. Dektol.

66. (449) Print processing in trays requires what type of agitation?

a. Random.
b. Continuous.
c. Intermittent.
d. Gaseous burst.

67. (450) Rinsing the developed print in a stop bath will not

a. slow development.
b. prevent blisters.
c. make the image permanent.
d. prolong the life of the fixing bath.

68. (450) Use of a non-hardening fixing bath when processing prints is recommended if you intend to

a. tone the prints.
b. produce prints for display.
c. process for archival quality.
d. process at high temperatures.

69. (451) Underdeveloping a print will not normally result in

a. a loss of detail in the highlight.
b. a low overall density.
c. a low contrast.
d. fogging.

70. (452) A lack of proper print agitation will not normally cause

a. stains.
b. mottle.
c. frilling.
d. low contrast.

71. (453) Stabilization paper is different from other types of printing papers primarily because it

a. has warm tones.
b. is high contrast.
c. is impregnated with developer.
d. has a greater variety of textures.

72. (453) Which stabilization solution develops the print image?

a. Developer.
b. Activator.
c. Stabilizer.
d. Intensifier.

73. (453) If stabilizer and activator solutions are mixed, what type of fumes are generated?

a. Formaldehyde.
b. Fosgean.
c. Ammonia.
d. Cyanide.

74. (454) The length of print washing time is affected by all of the following factors except that of the

a. method used.
b. weight of the paper.
c. amount of development.
d. temperature of the water.

75. (454) How many five-minute changes do you make when washing single weight prints in two deep trays?

a. 3.
b. 4.
c. 5.
d. 6.

76. (455) Most mechanical washers achieve agitation by

a. a combination of drum rotation and water spray.
b. use of hot water.
c. drum rotation.
d. water spray.

77. (456) Print curl is usually caused by

a. using a mechanical dryer.
b. rough handling of the paper.
c. the gelatin drying faster than the paper backing.
d. the paper backing drying faster than the gelatin layer.

78. (456) Print shrinkage is a special problem when

a. preparing mosaics.
b. printing on graded paper.
c. producing high contrast prints.
d. printing on variable contrast paper.

79. (456) Plumming can result from heat-drying photographic paper and cause

a. cracks to form.
b. the print to become brittle.
c. the print tone to become colder.
d. a matte print surface to have a sheen.

80. (457) Which of the following units is not a part of the Pakonomy Print Dryer, Model 26W?

a. A water circulating unit.
b. Two thermostats.
c. A motor drive.
d. A humidifier.

81. (458) When toning, which of the following should not be done?

a. Tone more than two prints at one time.
b. Select the tone to match the subject.
c. Agitate the print in the toning bath.
d. Wash the print after toning.

82. (459) When positioning the print on the mount, the border should be

a. wider at the top.
b. wider at the bottom.
c. wider along the sides.
d. the same width all around.

83. (460) For dry mounting black-and-white prints, the press temperature should be near

a. 315° F.
b. 235° F.
c. 200° F.
d. 175° F.

84. (461) When spotting glossy prints, special dyes are used to maintain the

a. tint.
b. tones.
c. gloss.
d. contrast.

85. (462) In which of the following ways should protective sprays not be used?

a. To improve the finish on the print.
b. In a well ventilated room.
c. Applied in thin coats.
d. To spot the print.

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CDC 23132

APPRENTICE STILL PHOTOGRAPHIC SPECIALIST

(AFSC 23132)

Volume 4

Photographic Application

Extension Course Institute

Air University

Preface

THIS FOURTH volume of CDC 23132, *Apprentice Still Photographic Specialist*, emphasizes the application of basic photographic principles to job assignments. In addition we delve into the operation of the Versamat processor, operator maintenance, color photography, and techniques of quality control.

Chapter 1 explains photographic composition. Many shots are spoiled by poor composition or a total lack of it. In this chapter we offer ideas and concepts of composition which you may use. We discuss creative techniques as well as basic concepts and corrective procedures. We will also cover the use of communicative symbols in composition as a means of conveying ideas.

Chapter 2 discusses the fundamentals of reproduction photography. The discussion covers the copying of reflective media and the duplication of transparent material. We have also added a small section on specialized copy procedures.

Chapter 3 covers photographic assignments. In this chapter we cover some of the actual photographic assignments which you may carry out. It is not our intent to lay down rigid rules on how you are to accomplish these assignments, but to point out certain techniques that you may find useful.

Chapter 4 covers the operation of the Versamat processor and operator maintenance.

Chapter 5 delves into the exciting world of color photography. We discuss the principles of color photography, exposure and processing, and color chemical mixing as well as color printing and finishing.

Chapter 6 discusses quality control. While cleanliness is uppermost, there are other means and standards to observe to assure that a satisfactory photographic product is being produced.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTOC, Lowry AFB CO 80230. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 36 hours (12 points).

Material in this volume is technically accurate, adequate, and current as of November 1975.

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objectives gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Principles of Photographic Composition

COMPOSITION, IN ITS broadest sense, means the organization of all the elements in a photograph to create an effective, comprehensive whole. More specifically, composition means the arrangement or organization of the various picture elements—lines, colors, tones, textures, shapes, and volumes—into a unified design (fig. 1-1). The proper arrangement of these elements takes place in the viewfinder or on the ground glass.

In this chapter we will discuss the basic concepts of composition along with corrective, creative, and communicative techniques.

1-1. Apply Basic Concepts

The photographer should have an idea of what he wants as a final photographic result as he moves into position to shoot. All subject elements should be properly arranged with consideration given to the lighting and the appearance of the various tones and textures. Many distracting elements can be eliminated by applying the principles of good composition at this point. It will be very difficult, if not impossible, to correct mistakes caused by choosing the wrong camera angle or poor arrangement at a later point in the photographic process. The photographer should therefore do his cropping and composing before he trips the shutter.

600. Explain principles and techniques which are used to achieve effective composition.

Although good composition is something that each photographer must learn to feel for himself, you can consistently produce good quality photographs by using these basic guidelines for composing your picture.

Point of Interest. Every photograph should have one definite point of interest. If the viewer is distracted by a jumble of elements, the main subject of the photograph will not stand out. (See fig. 1-2.) This makes it difficult to determine the purpose of the photograph. The point of interest may be a single object or consist of several elements. The key is that all parts should be arranged so that the viewer's attention is drawn directly to the subject. (See fig. 1-3.)

Simplicity. One sure way to emphasize your subject is to simplify by minimizing the number of elements presented in the picture. As we have said before, the camera lens sees everything that exists in front of it. Therefore, adjust your camera angle and camera-to-subject distance until all but the essentials have been eliminated from your picture. As a start toward simplification: (1) move closer to your subject, (2) choose a plain background, and (3) let the lighting emphasize your subject. Compare figures 1-4 and 1-5 to see the improvement that simplicity can make.

Horizon Line. Most outdoor, and many indoor, photographs have a real or imaginary horizon line—the line where the sky seems to meet the earth or where the foreground or middle ground meets the background. The proper placement of the horizon line will help you arrange the background, the foreground, and the main subject areas of your picture. You should try to keep the horizon line level. (See fig. 1-6.) Next, try to remember never to place the horizon line in the direct center of the photograph. If you do, you divide the photograph into two equal parts and produce a dull and uninteresting picture. (See fig. 1-7.) Try to position the horizon line above or below the exact center of the photograph. A high horizon line gives the appearance of depth and distance. (See fig. 1-8.) A low horizon line creates an appearance of increased height. (See fig. 1-9.)

The Golden Mean. The Greek sculptors and the great painters and architects of the middle ages used what has been called "The Golden Mean" (fig. 1-10) to help them establish correct proportion and placement of their subjects. We can apply this principle in photography by dividing our rectangular picture area into thirds, both horizontally and vertically. Then we can place our horizon line on, or close to, one of the 1/3 lines while placing our subject on one of the four intersecting points. (See fig. 1-11.) Some photographers actually draw lines on their ground glass to apply this principle.

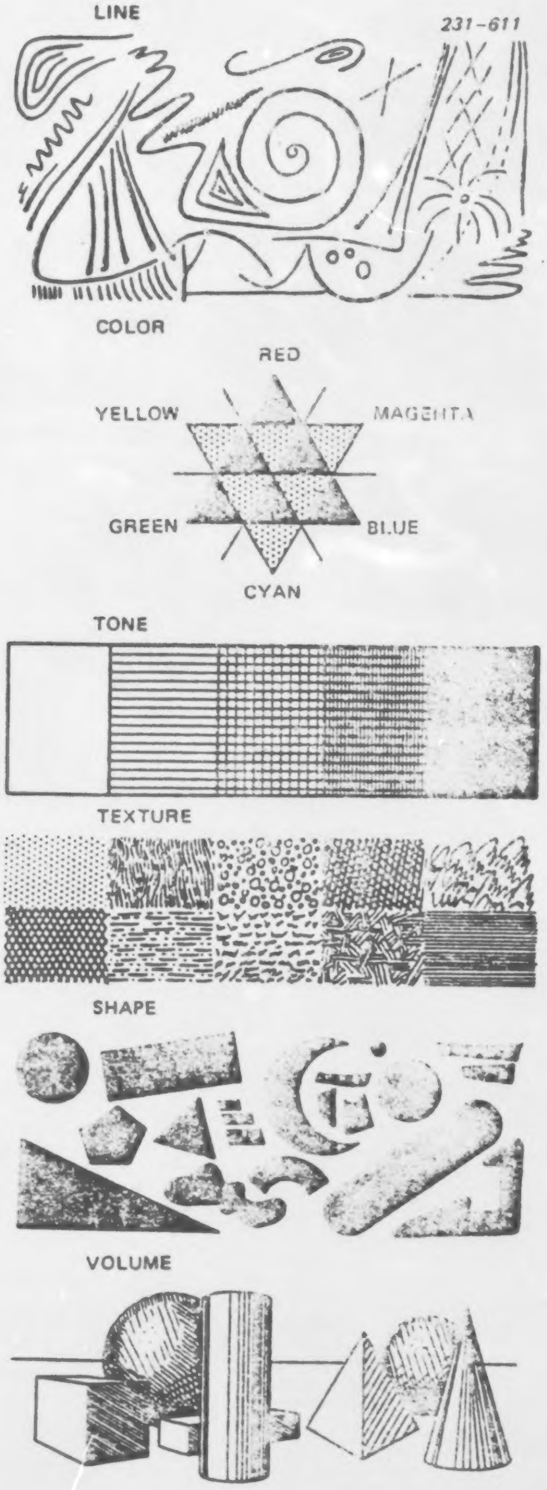

Figure 1-1. Compositional elements.

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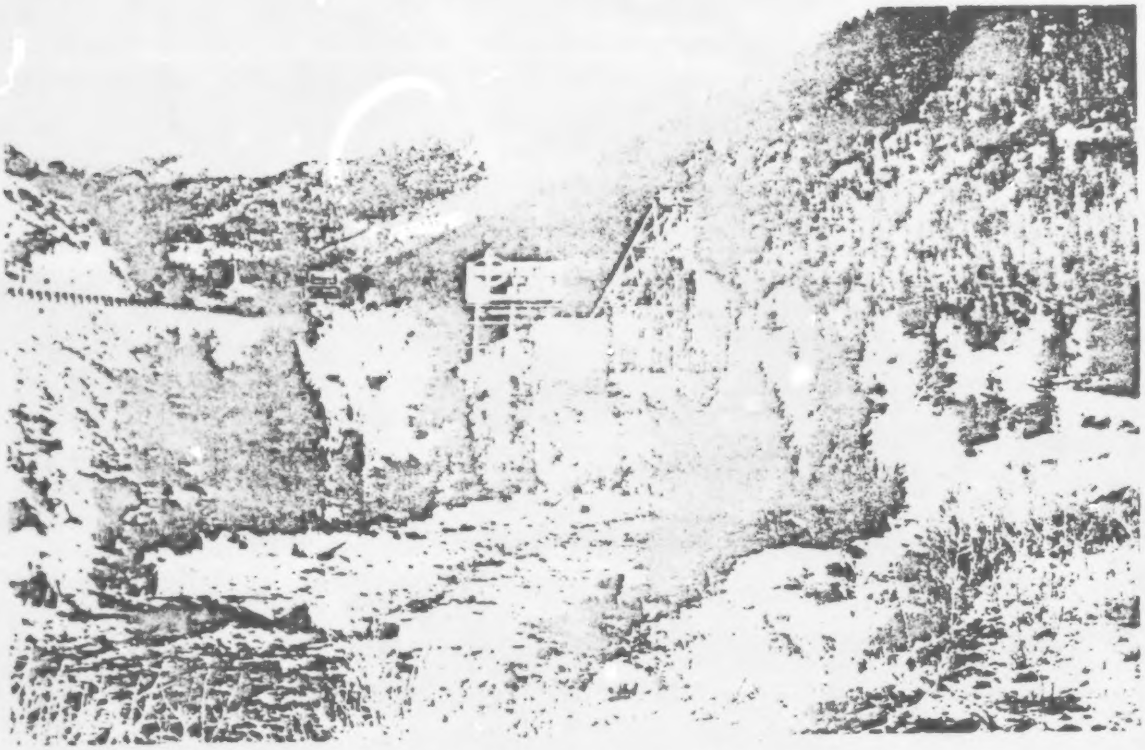


Figure 1-2. A scene having no definite point of interest.

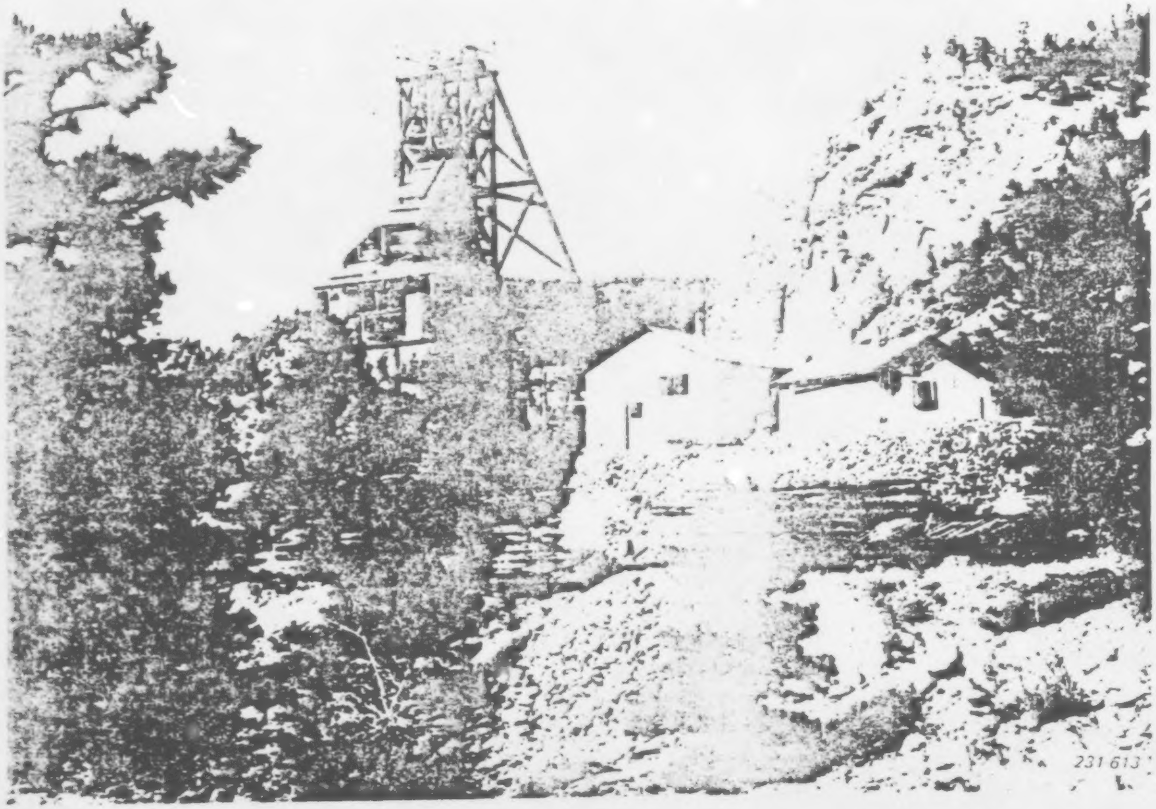


Figure 1-3. A scene having a definite point of interest.

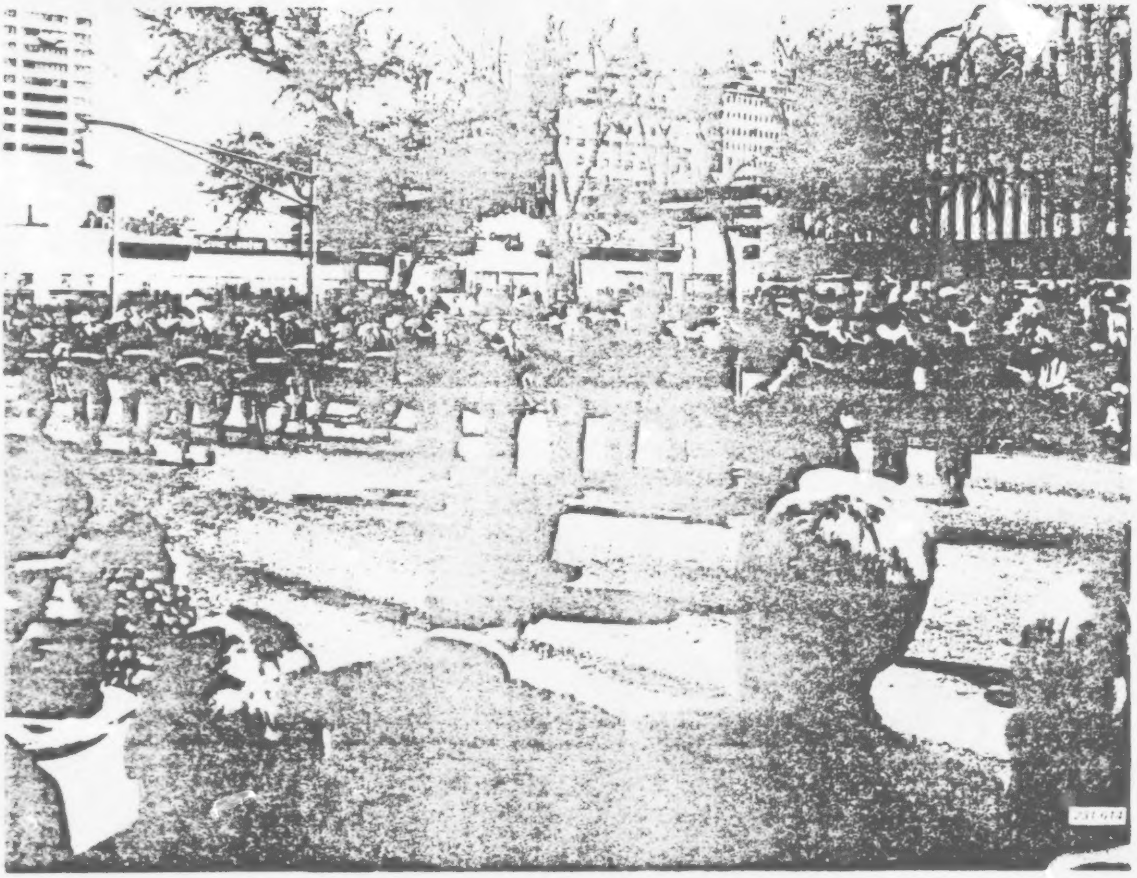


Figure 1-4. A complex picture lacking simplicity.

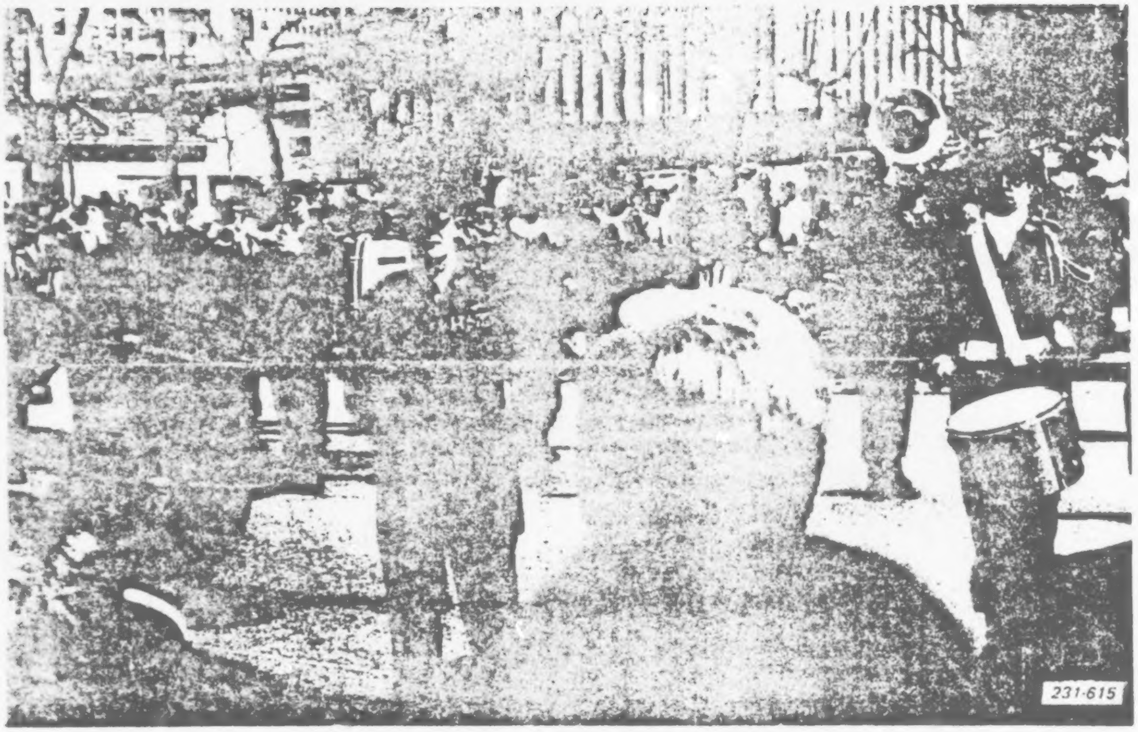


Figure 1-5. A photograph showing the use of simplicity.

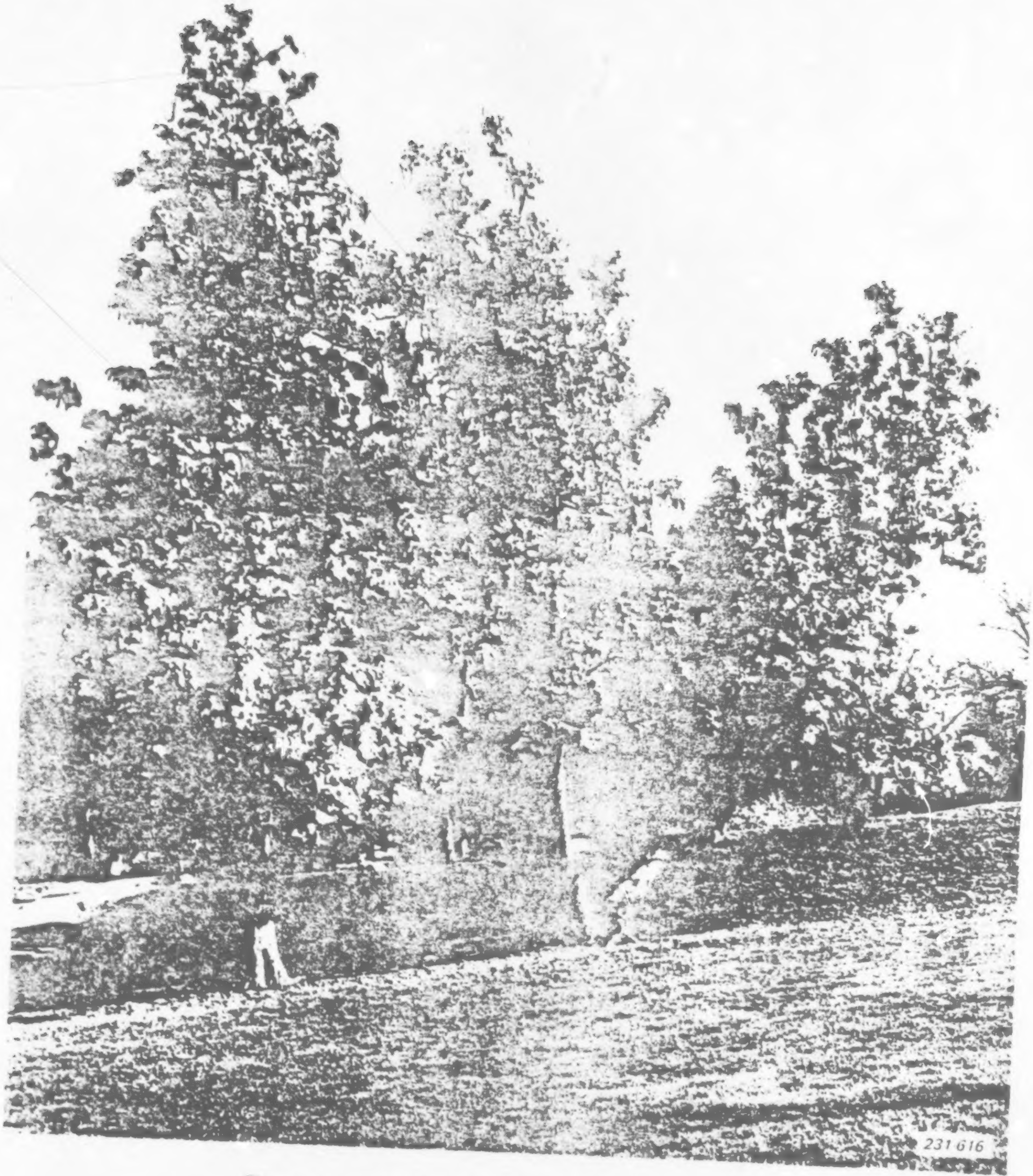


Figure 1-6. A crooked horizon line leads to an awkward composition.

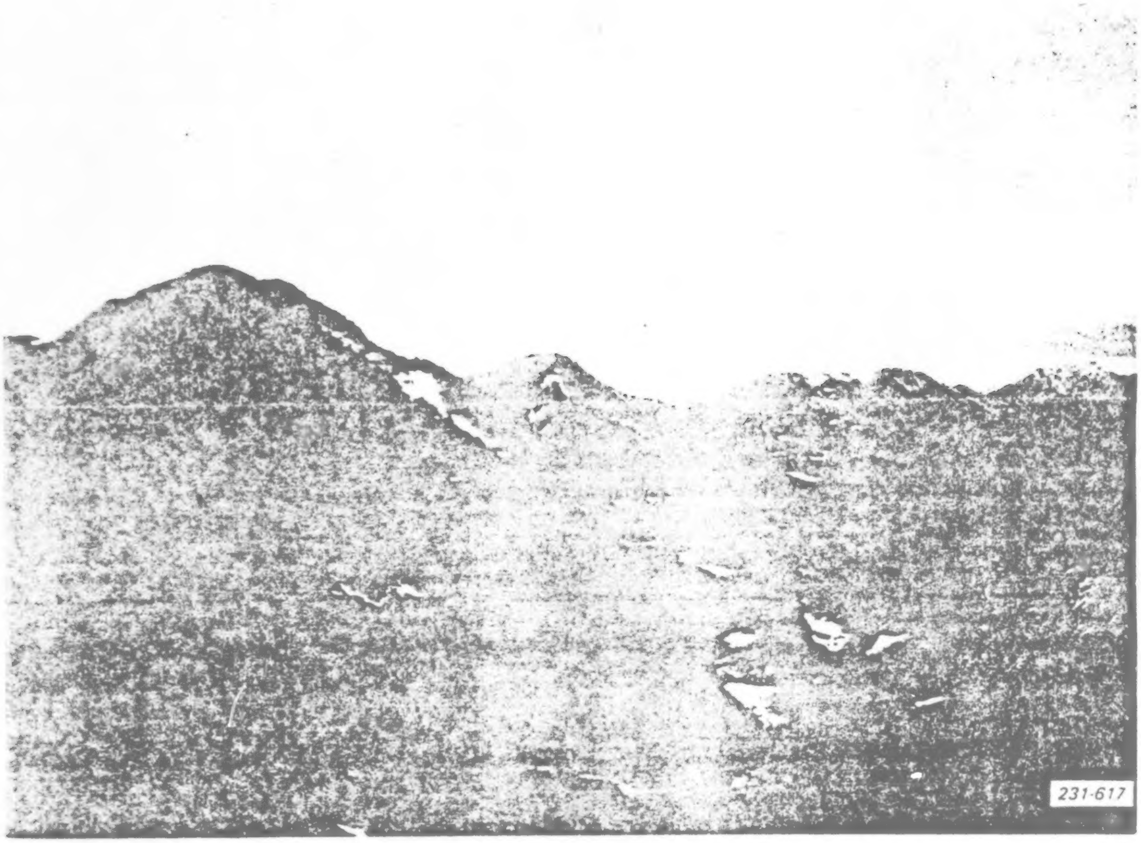


Figure 1-7. A horizon line that divides the subject in half leads to dull pictures.

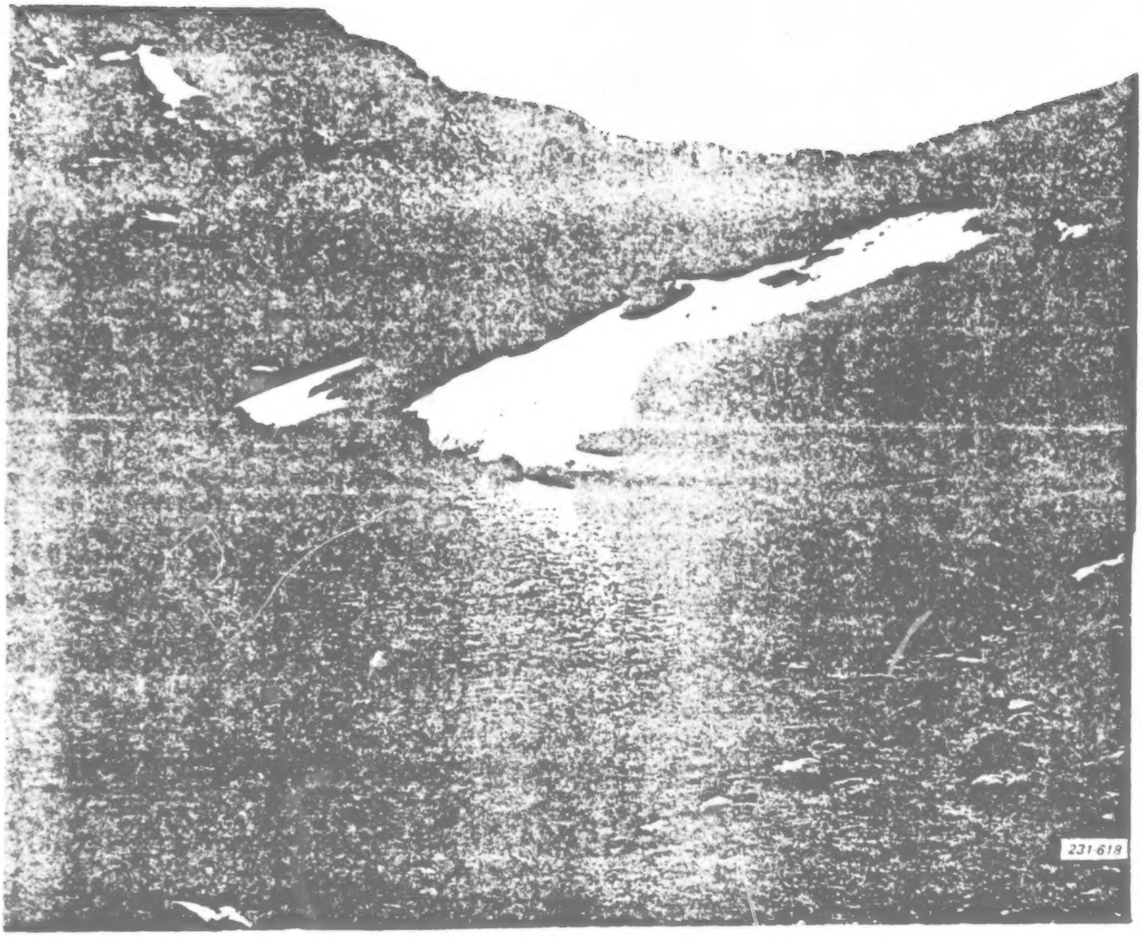


Figure 1-8. A high horizon line emphasizes depth.

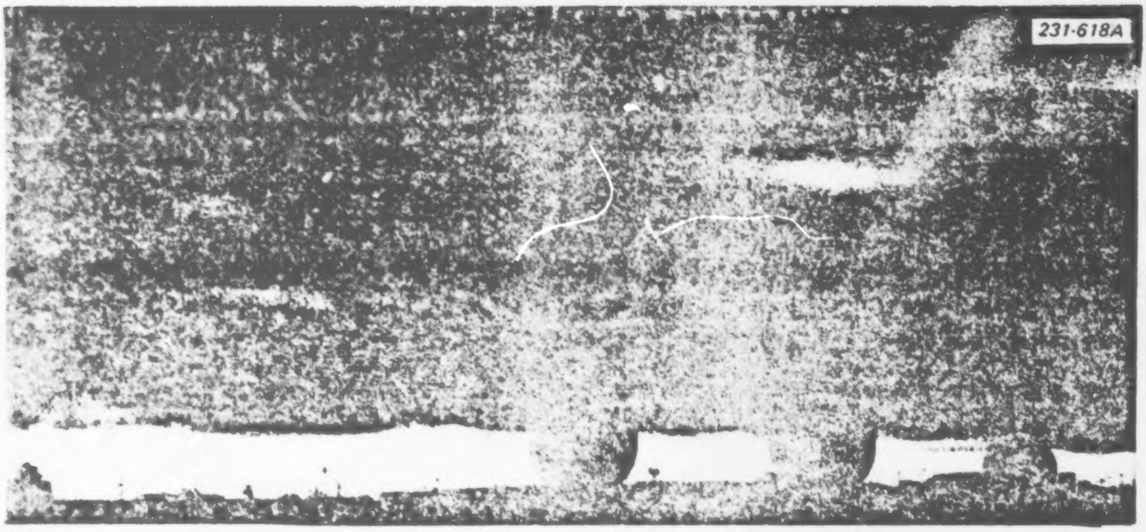
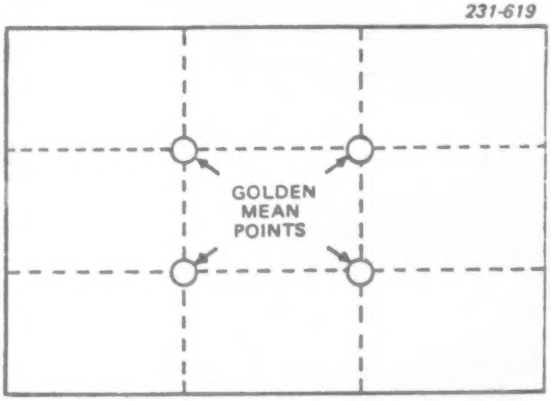


Figure 1-9. A low horizon line emphasizes height.

Leading Lines. One of the most common techniques in directing attention toward the point of interest is the use of leading lines, shapes, or patterns. A leading line may be any object, or any series of objects, which tends to direct the observer's eyes toward the point of interest. It may be a road, a fence, a row of trees, a shoreline, or even a patch of light or dark tone in the scene. An ideal leading line is one that starts near a bottom corner of the scene and continues unbroken until it reaches the point of interest. (See fig. 1-12.) It should end at this point, otherwise the observer's attention will be carried beyond the main object in the picture.



1–DIVIDE THE COMPOSITION INTO THIRDS
2–PLACE THE HORIZON ON OR CLOSE TO THE ONE–THIRD LINE
3–PLACE YOUR CENTER OF INTEREST AT ANY GOLDEN MEAN POINT

Figure 1-10. The "Golden Mean."

Framing. Another very effective method of confining attention to the point of interest is by framing it with such objects as trees, columns, a doorway, an arch, or a window. For example, looking across a broad expanse of land or water at a house can give an observer a rather dull, uninteresting view; while, by moving back a few feet and framing the same

Figure 1-11. Photographic illustration showing the placement of the subject according to the "Golden Mean."

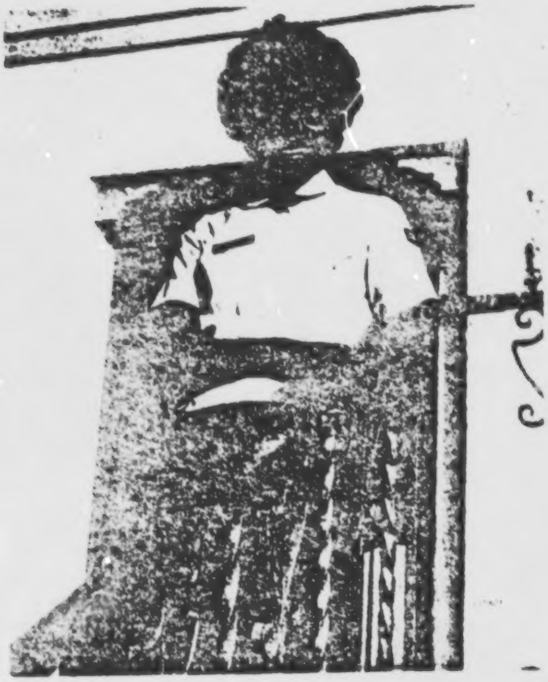


Figure 1-12. Using a leading line to direct the eye to the point of interest.

house between clumps of trees may improve the composition. (See fig. 1-13 to see how framing can be used.)

Handling of Action. A photograph depicting action or movement of any kind tends to lead the viewer's eyes in the direction of the action, consequently your composition is strengthened if the action leads into the photograph. Action shots require correct shutter speed selection and careful camera handling. A fast shutter speed creates a stop-action effect, while a slow shutter speed makes the subject blurry. (See figs. 1-14 and 1-15.) If the camera is held still, the subject may appear blurred while the background remains sharp. If the camera follows the action (panning), then the subject will appear sharp and the background will appear blurred. Panning can be used to stop rapidly moving subjects. (See fig. 1-16.)

Balance. In a well-balanced picture, the position of the various elements of the photograph gives harmony to the whole setting. Your problem with balance is to arrange the various objects into a specific design. There are two types of balance: formal (symmetric) and informal (asymmetric).

Formal balance is achieved by arranging elements having similar size or shape on either side of an imaginary central dividing line in order to produce a

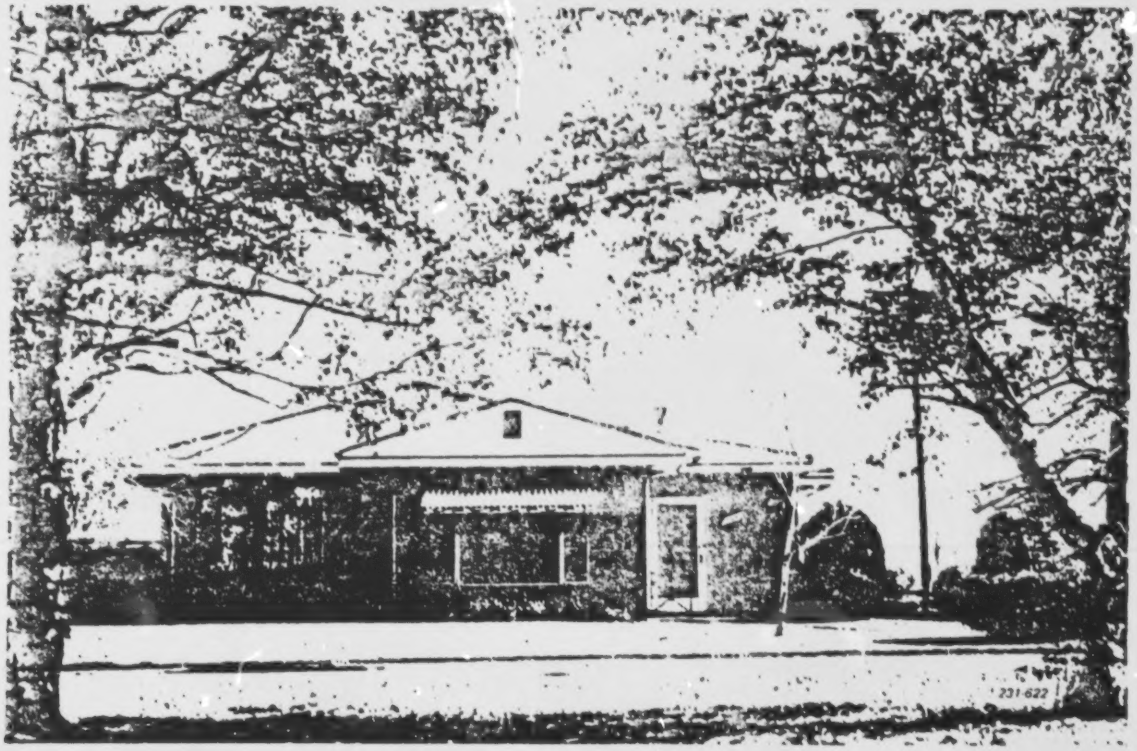


Figure 1-13. Using trees to frame a house to make it stand out.

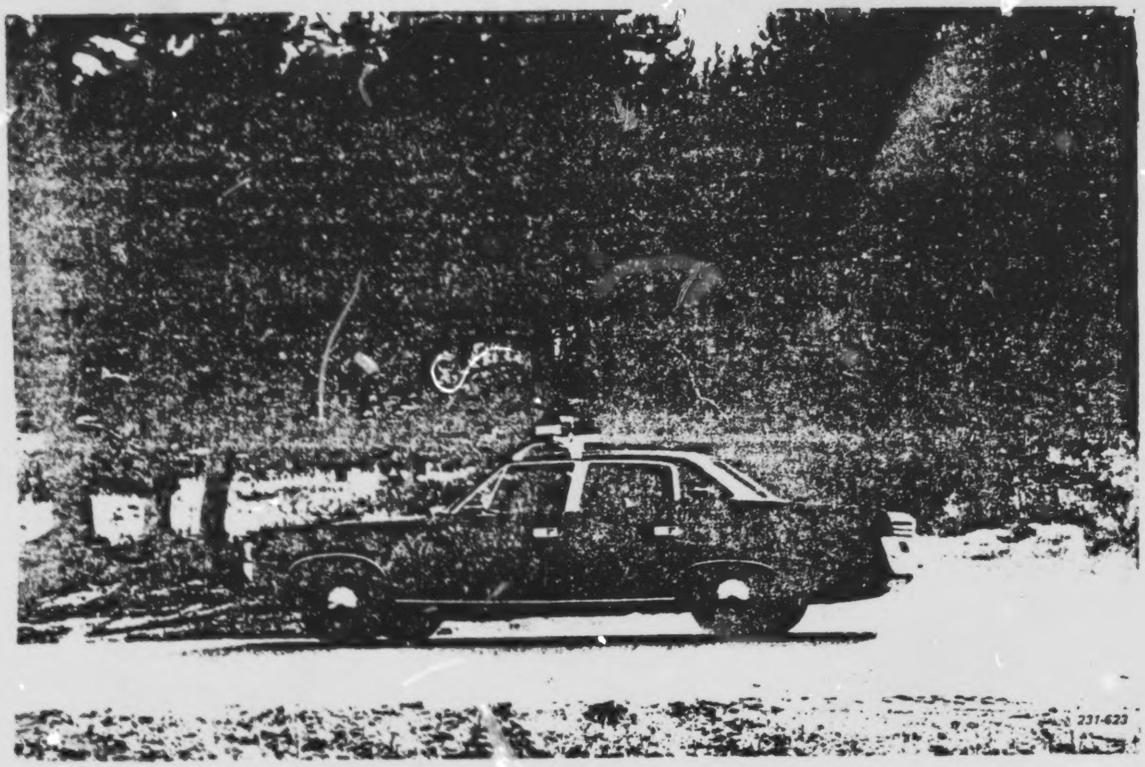


Figure 1-14. A fast shutter speed creates a stop-action effect.

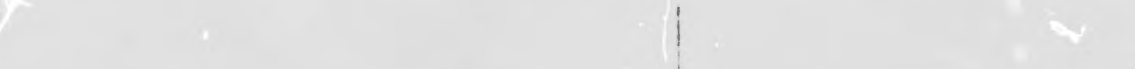


Figure 1-15. A slow shutter speed blurs the action.

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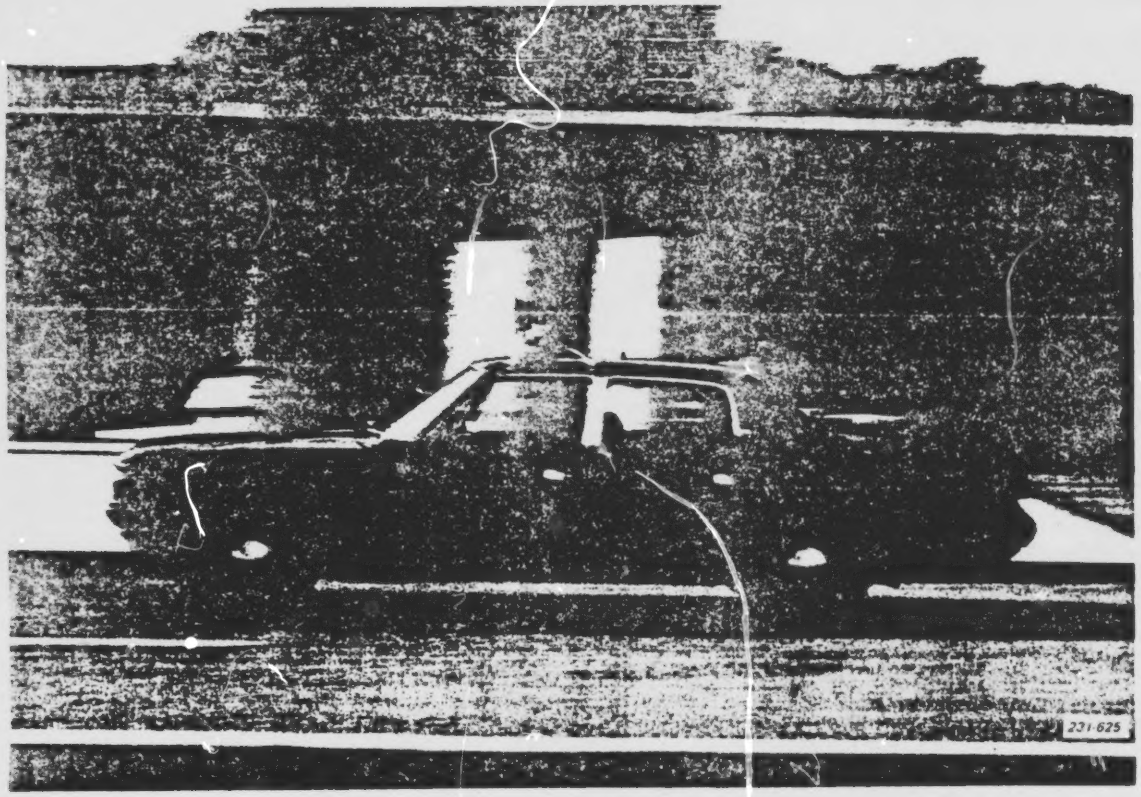

Figure 1-16. Panning provides a sharp subject while blurring the background.

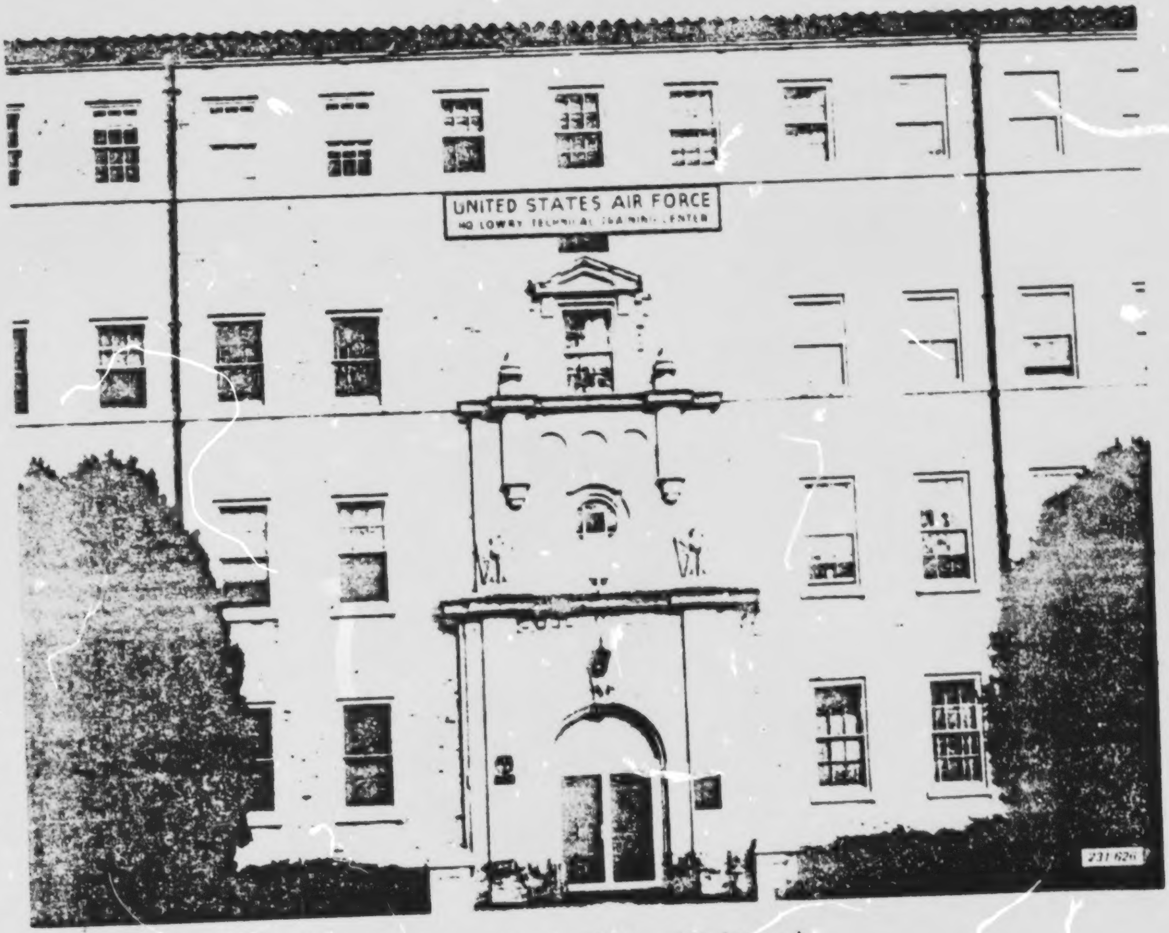

Figure 1-17. Using formal balance in a photograph.

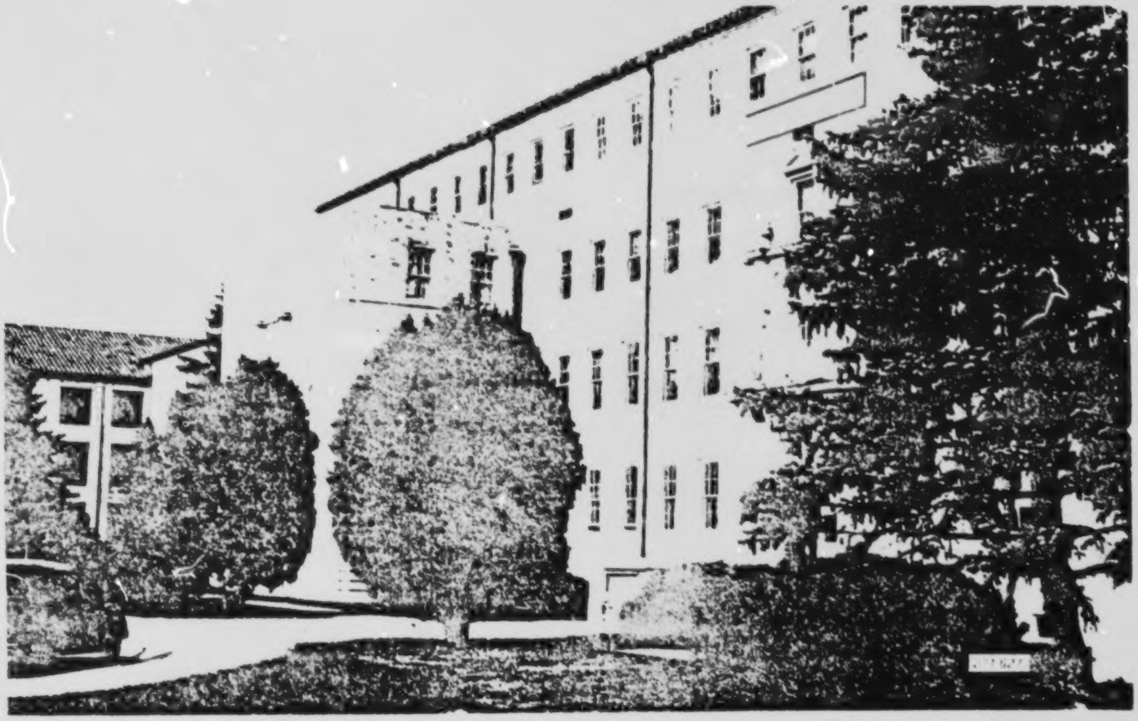

Figure 1-18. Using informal balance in a photograph.

balanced relationship within the composition. (See fig. 1-17.) Generally speaking, this type of balance should be avoided, since it usually fails to stimulate the viewer's interest. For example, although a single subject placed in the exact center of the photograph provides the simplest kind of balance, this should be avoided for the reason just given. We can sum up formal balance by saying that it is dividing a composition into equal parts, with none of the parts being dominant. Although this is sometimes pleasing to the eye, it quickly becomes monotonous through overuse.

In contrast, informal balance involves a pleasing relationship between dissimilar forms and/or subject arrangements. For example, a smaller area or object can balance a much larger one if the smaller area contains a form or subject that attracts the viewer's attention more than anything contained in the larger area. You can cause attention to be focused on the smaller area by varying the color, texture, tone, shape, or activity in the two areas. (See fig. 1-18.)

Format. Format determines the shape of the photograph. It may be horizontal, vertical, or square. Format is important, and your selection will influence both the appearance and the meaning of the photograph. Here are a few suggestions concerning the choice of format. If the shape of your subject indicates a given format, use that format. For example, tall objects usually fit a vertical format, whereas wide objects require a horizontal format. A square format is, however, rarely used. Remember, you can achieve a different format easily and quickly by turning your camera, changing the position of the camera's revolving back (example—Super Speed Graphic), or changing your easel during printing.

The Third Dimension. Perspective is defined as the rendering of a three-dimensional subject (height, width, and depth) on a two-dimensional surface (height and width). This problem faces both painters and photographers. The main challenge is to retain a feeling or illusion of depth. There are four means of expressing depth in composition. These are line, figure, light, and haze effects. (See fig. 1-19.) A leading line going into the picture (road, river, or a fence, etc.) can create a feeling of depth. The relative size of the subject matter can also help to create the illusion of depth. For example, objects in the background look smaller and farther away even though they are of the same size. This is so because we know that the reduction in image size is caused by an increase in distance. Lighting can also be used to help create the appearance of depth. Long shadows cast into the picture promote a feeling of distance. Finally, a diminishing sharpness, caused by haze, can give the feeling that the background is far away.

Subject Size. Your ability to decide how much of

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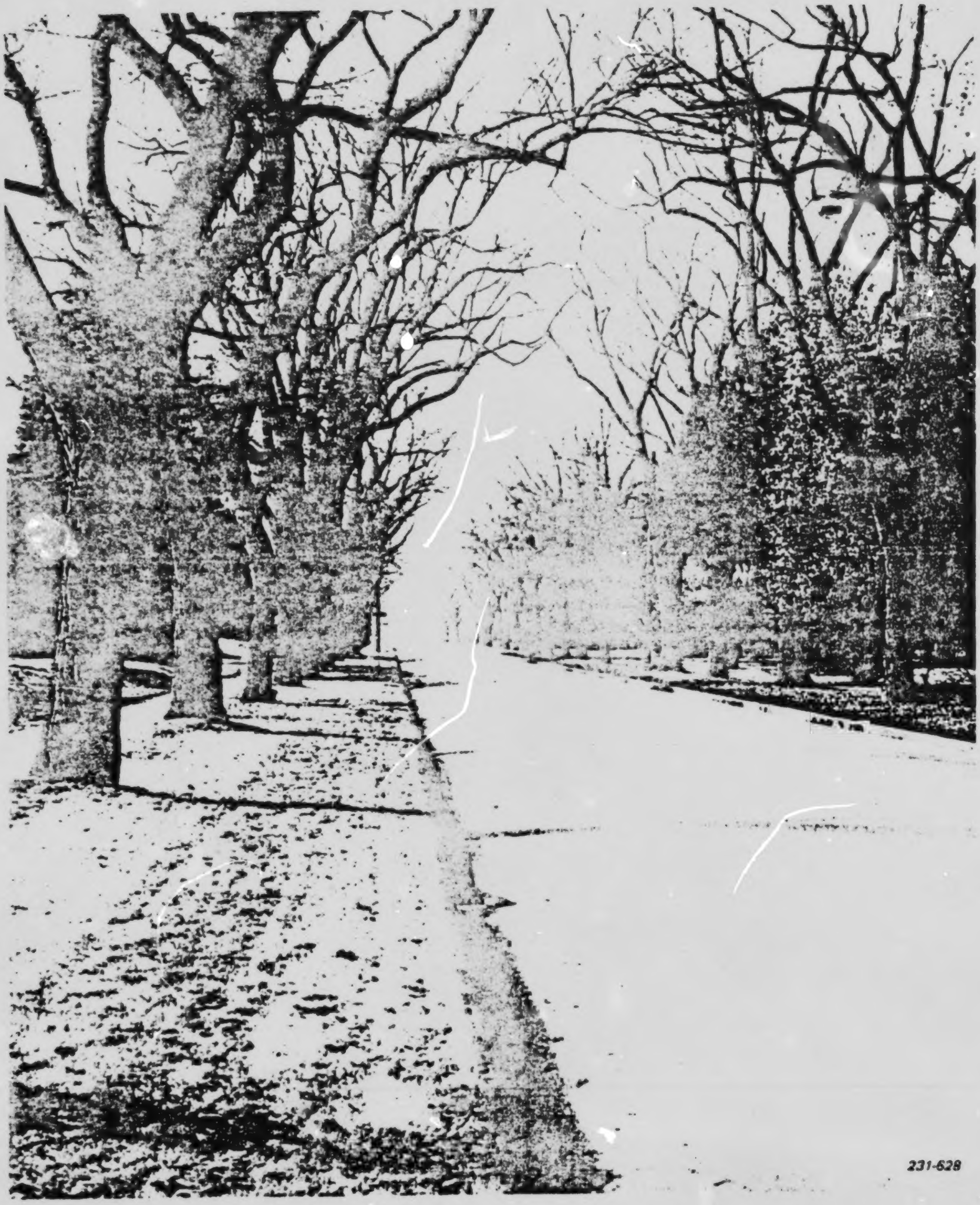
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Figure 1-19. Use of lines, light, figures, and haze gives a feeling of depth.

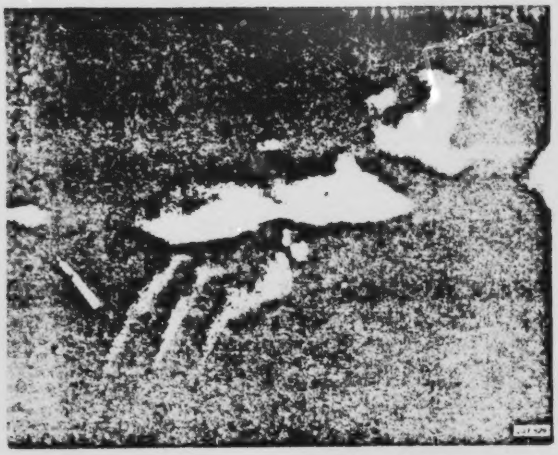


Figure 1-20. The effect of foreshortening.

the subject should be included in any photograph is very important. For example, you can photograph just the subject itself or only part of the subject. You can make the subject small and include much of the surrounding area. Generally, however, you cannot go wrong if you make your subject as large as possible. When you check the viewfinder or the ground glass, you may find that much of the area surrounding the subject is not an important part of the picture and can be eliminated. In fact, eliminate everything that is not absolutely essential to the purpose of the photograph. This applies to parts of the subject itself. If a picture is correctly composed, you cannot add or subtract anything without adversely affecting the quality of the photograph.

Background Control. Many photographers overlook the background during composition of the photograph. When the finished print is examined, however, the viewer will quickly realize that the background should have been taken into consideration. This is especially true if the background contains elements that distract from the main subject. Through neglect, the background may destroy the quality of your subject arrangement. Therefore, look beyond the subject and check the background area. In some instances the background will be inappropriate, cluttered, or disorganized. If this is the case, you will have to exercise background control. You can do this in several ways. For instance, you can (1) move the subject to another location, (2) change the camera position, (3) change the camera angle, (4) remove the objectionable background from the composition, or (5) throw the background out of focus by using a large aperture (i.e., limited depth of field.)

Foreground Control. Like the background, the foreground is important. In most cases, the foreground should be in focus and be of sufficient depth to support the subject. Don't let foreground objects detract from the point of interest. As a rule, the foreground will contain the leading line. Consequently, a fuzzy, out of focus foreground will irritate the viewer and detract from the point of interest. Occasionally an out of focus foreground is used in portraiture where the foreground forms a frame for the subject's face.

Tone Balance. In black-and-white photography, the subject's colors and those surrounding it are presented as various shades of gray in the final photograph. Remember, the shade of gray produced depends on how much light the subject is reflecting. It is important that tones, especially those close together, do not blend and obscure detail. This problem can be avoided by making a slight change in your camera position or by using a filter or supplementary lighting and controlling film contrast during processing.

Exercises (600):

1. Why should every photograph have a clear point of interest?

2. What are three techniques that can be used to achieve simplicity in composition?

3. A high horizon line conveys what feeling?

4. What is the purpose of a leading line?

5. What will be the visual effect if you pan when photographing a moving object?

6. Haze in a scenic will help create what effect?

7. How are filters used in tone control?

1-2. Use Corrective Procedures

"Corrective procedures" are used to attain the desired perspective in a photograph through the use of various camera adjustments. Perspective is the art of picturing objects or a scene in such a way as to show them as they appear to the eye with reference to relative distance or depth. What does this mean to you? Since photography is two dimensional, we have to create an illusion of three dimensions with photographic techniques. We also must maintain relationships between various picture elements so that they have a natural appearance. Perspective control is therefore the most important corrective technique that is used to achieve pleasing compositions.

601. Define the terms "diminution" and "foreshortening," explain how foreshortening in portrait work can be prevented, and explain the value of a view camera in corrective photography.

Whether a particular photograph looks natural or not often depends upon how we have been trained to see. For example, we accept the convergence of parallel lines in the horizontal. This commonly happens when we view the "narrowing" of railroad tracks as they recede in the distance. However, we do not accept the same phenomenon in the vertical. For example, if a photographer tilts his camera upwards in order to capture the top of the building, the walls of the building appear to converge toward the top and the building seems to be falling. The photographer, therefore, must be able to control the appearance of these parallel lines in his photograph to maintain a pleasing perspective.

Perspective is controlled by the camera position. Camera position controls the angle of view and the subject-to-camera distance. The choice of lens focal length, while not controlling perspective, can be helpful in maintaining the desired image size while allowing a change in camera position. In our tilting building example, the problem could have been avoided by using a suitable wide angle lens to give the necessary coverage or by moving far enough back so the available lens could give the coverage without the need for tilting.

Another type of problem is diminution. Objects in the background look smaller than those in the foreground even though they are of the same size. This, again, can be controlled to some degree by changing camera position and using the appropriate focal length to insure a useful image size.

Foreshortening is a form of distortion whereby foreground objects appear to be disproportionally large. This often happens when a photographer moves in close with a normal or wide angle lens to maintain a large image as in portrait photography. To correct this "problem" the photographer should step back and use a longer focal length lens.

It must be stressed that various types of "distortions" may be effective. For example, diminution gives a feeling of depth while foreshortening can be used to give a feeling of space. (See fig. 1-20.)

The key to perspective control is the camera position in relationship to the subject. The view camera, with its many adjustments, permits complete perspective control without the need to always "move" the camera from one position to another. Complete camera movement is provided by the set of swings, tilts, slides (shifts), the rising and falling front, and the rotating film back. These many adjustments enable you to accomplish the following tasks:

a. You can control perspective and deliberately prevent, moderate, or exaggerate distortions.

b. In photographs taken at an angle, you can extend sharpness in depth.

c. You can also change the position of the image on the film without changing the position of the camera.

The view camera, therefore, is the choice for corrective procedures to achieve distortion free composition. Too many photographers, however, shy away from the view camera because of its bulk and many adjustments. The best way to be at ease with the camera is to practice with it before a job comes up. For example, you can arrange a simple still life in the studio. Using the camera straight on, with all the adjustments in neutral, focus on the subject. Take a picture with Polaroid film. Then use each of the adjustments one by one until you can clearly see the effect that each has on the result. Take a Polaroid photograph with each step. You can repeat this same process with an architectural shot. In this way, you will have a folder of pictures to refer to when you are getting ready for an assignment. Remember, knowledge gives you confidence.

NOTE: Limited corrective photography can be achieved with a 35mm camera (e.g., Nikon) equipped with a perspective control lens. Such a lens can be adjusted out of the normal axis to control parallel lines, etc. This can be invaluable when you need color slides as an end product.

Exercises (601):

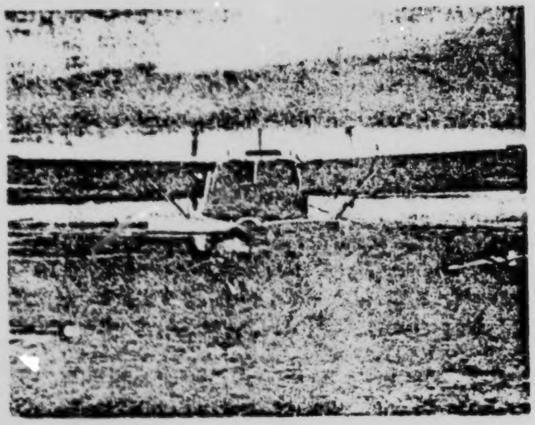
1. Define diminution and foreshortening.

2. Explain how foreshortening can be prevented in portrait work.

3. Explain why a view camera is ideal for corrective photography.

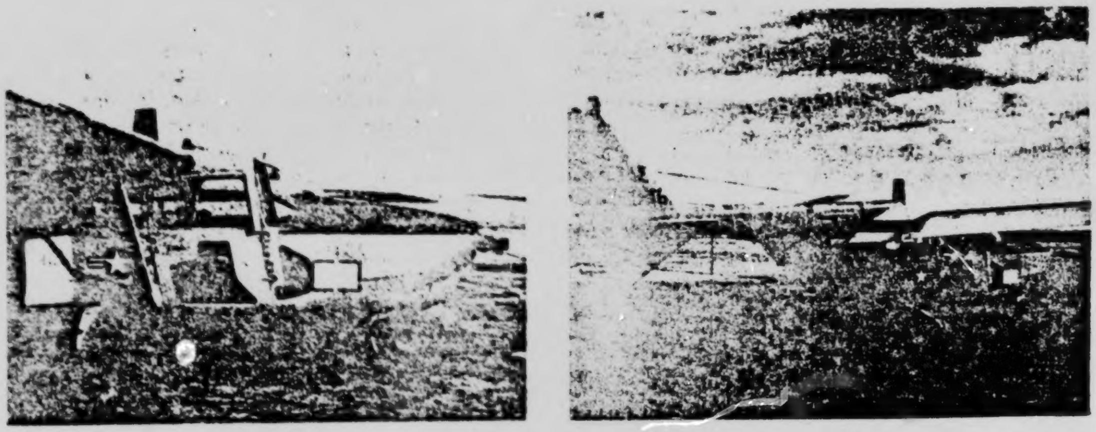
1-3. Use Creative Techniques

To be creative means to be able to be productive; to achieve what was not there before; to assemble different elements in an effective and novel way. Every photographer should try to be as thoughtful as possible on every shot. In this section we will discuss a few



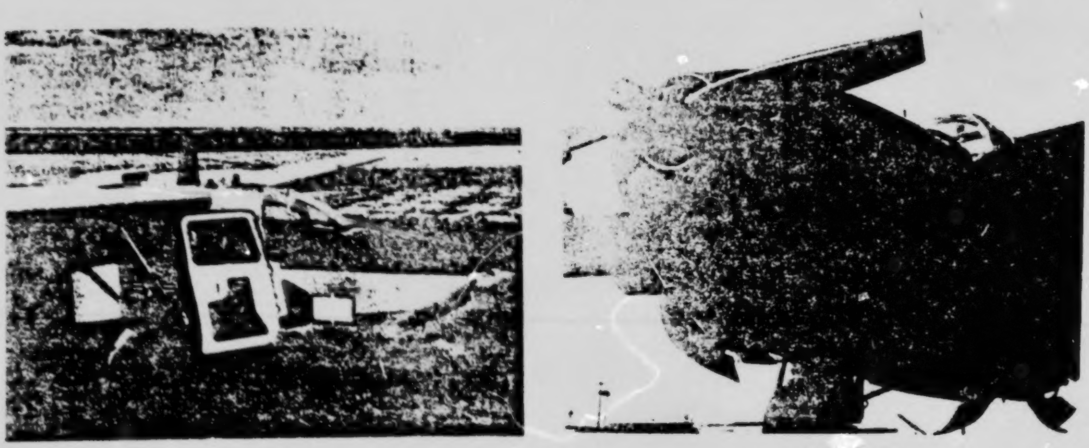
A. FRONT

231-630



B. SIDE

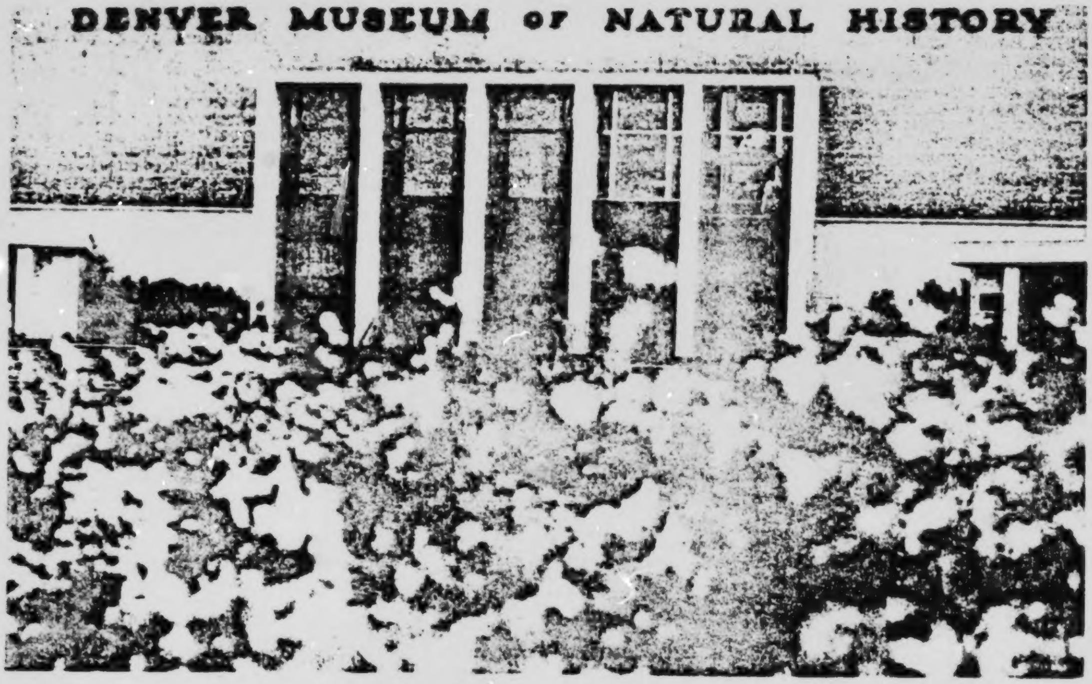
C. BACK



D. TOP

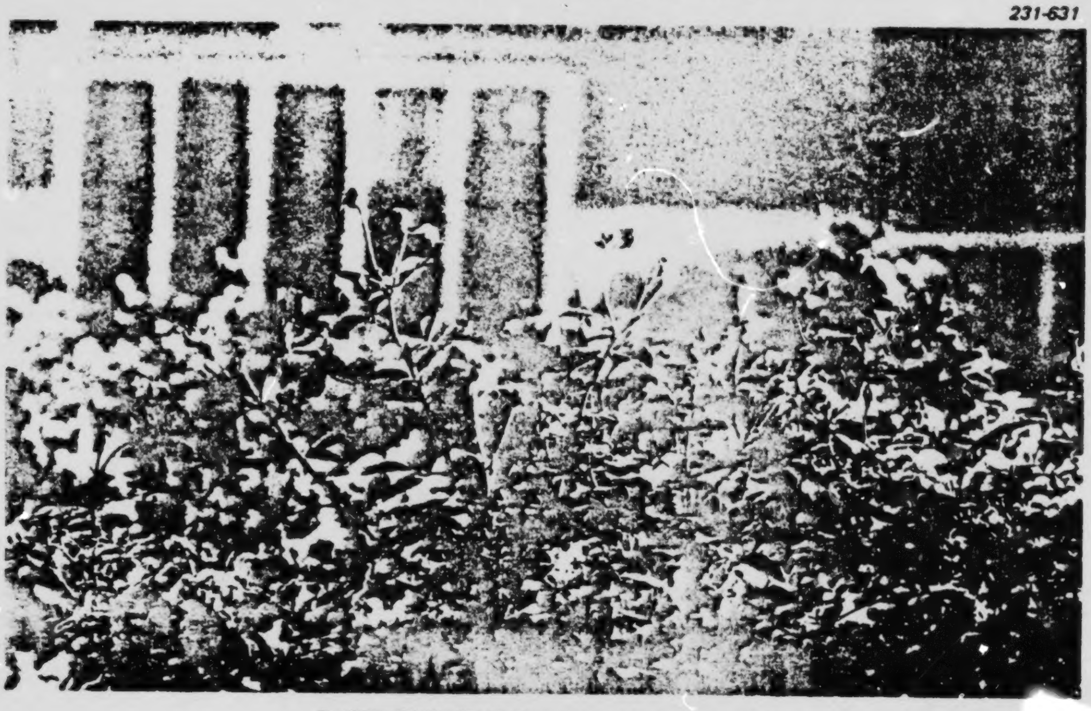
E. SHOOTING UP

Figure 1-21. Using various camera angles to achieve effective composition.



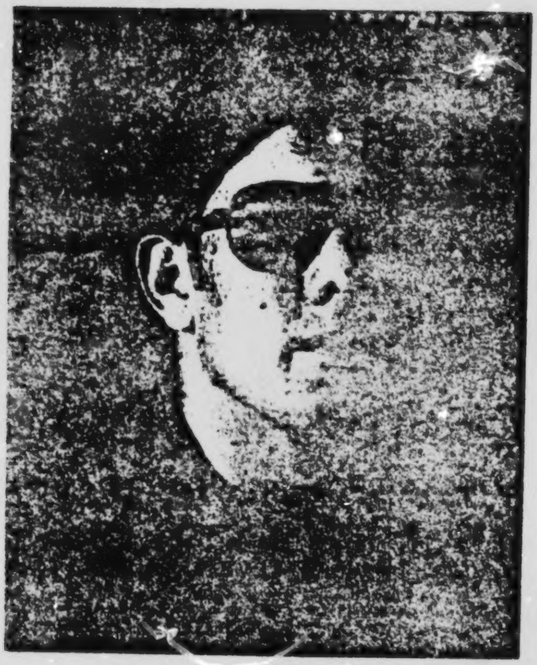
A. FOCUSING ON THE BACKGROUND SUBJECT

231-631



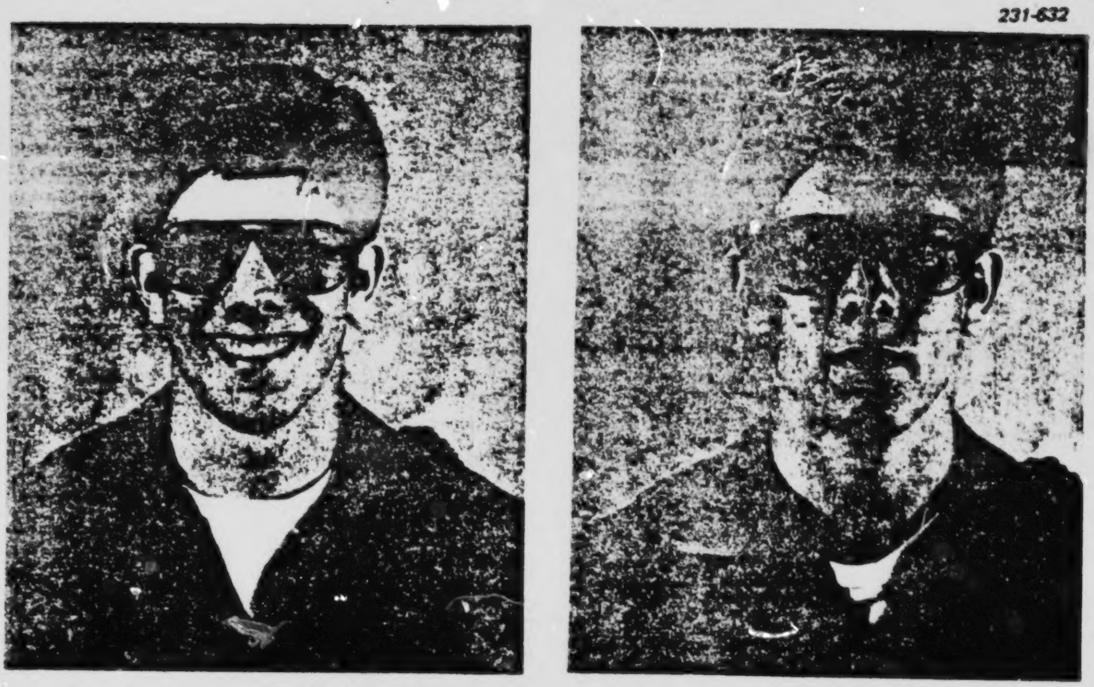
B. FOCUSING ON THE FOREGROUND SUBJECT

Figure 1-22, A&B. Selective focus (common title).



A. COLD EFFECT, HIGHT CONTRAST

231-632



B. WARM EFFECT, MEDIUM CONTRAST

C. FLAT EFFECT, LOW CONTRAST

Figure 1-23. Using tones and contrast to create a visual effect.

ideas you might consider trying when you wish to achieve better results.

It must be stressed that in the area of composition there are no firm "DO's" and "DON'Ts," just guides to help solve a visual problem. The best way to improve one's "eye" is through practice. Practice can take many forms. One way is to give yourself "self-assignments," like shooting a "little league" game in a refreshing way. Shooting, processing, and printing your work, followed by a thorough critique, is the best way to get better. In conjunction with this, the study of the work of leading photographers, painters, cinemaphotographers, and sculptors, who communicate a visual message, will provide much food for thought.

While the mastery of the various photographic skills is essential, one's attitude is the most vital ingredient. A willingness to learn, a desire to improve and demand upon oneself to accept nothing but one's best efforts, provides the power to go forward.

602. Explain how different camera angles, use of equipment, selective focus and depth of field, and tone and contrast can help you achieve creative results.

The following five topics are just to give you some ideas that you might consider when carrying out your assignments. Though we often stress equipment and particular techniques, it is the photographer and his visual insight of the subject in photographic terms that make the difference. YOU are the difference.

Camera Angles. Camera position is a most important choice in determining how a subject will appear. To achieve effective composition, it is best if you can take pictures from several camera angles. Do a 360° walk around the subject to get a clear idea of the possibilities. Then produce a variety of shots. Shoot up, down, left, right, front, back, three-quarters, etc. Each angle may show the subject in quite a different light. For example, shooting up makes the subject more imposing whereas shooting down will make the subject appear smaller and less important. The point being stressed is that if, for example, you take all your shots from the front at eye level your compositions will become monotonous. In figure 1-21, look at the effect that a variety of camera angles can have on how you see the subject.

Interrelationship of Subject Matter Parts. The more objects that are in the picture, the more challenging it is to achieve a harmonious arrangement. Many times you will not be able to move the subject and must depend on camera angle, shooting distance, lens selection, etc., to achieve a pleasing composition. When you can arrange the subject matter, the arrangement rather than the "taking of the picture" will likely make the difference between success and failure.

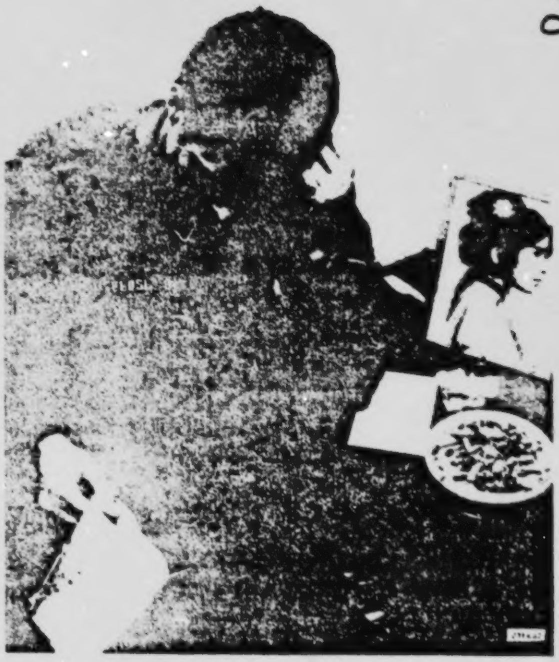


Figure 1-24. What does this photograph communicate?

Use of Equipment. The proper selection of equipment can help you effectively complete your assignment. Filters, lenses, and lighting equipment all can help to achieve unique results. A "fisheye" lens can give you a cylindrical picture, a diffusion filter will soften the image or a multi-image filter can give you special effects. You must therefore be aware of the continuing advances in equipment that permit you to extend or achieve a particular vision.

Selective Focus and Depth of Field. What should appear sharp in the photograph? The point of critical focus and the degree of depth of field will determine just how much of the photograph appears sharp. What appears sharp will certainly affect the character of the point of interest. The difference that can be achieved by changing your plane of focus is illustrated in figure 1-22, A and B.

Tone and Contrast. In black-and-white photography, the rendering of the subject in various shades of gray and the contrast relationship of these shades is very important in determining the final visual effect. The selection of the subject, background, foreground, and lighting creates a critical combination. Remember, the tone of each element will be determined by how much light it reflects. The more light, the lighter will be the tone. In this regard the appropriate use of a filter can be particularly helpful, especially when different colored objects may be reflecting the same amount of light. The selection of your film/developer combination will also have an important bearing on your recording. It is best to think about all of this when you are shooting, rather than rely on darkroom manipulation. Notice the difference that tones and contrast make in figure 1-23.

NOTE: In color photography the relationship of all the different colors is of great importance on what impact the photograph will have on the viewer. In fact it is the pattern of colors rather than the form and content of the subject matter that often dominates.

These have just been a few suggestions you can consider. See what YOU can do. Take PRIDE in your work. Always be in "student status" so that your work will not get stale.

Exercise (602):

1. Briefly explain how each one of the following is used to achieve creative compositions:
   a. Camera angles

   b. Interrelationship of subject matter parts

   c. Use of equipment

   d. Selective focus and depth of field

   e. Tone and contrast

1-4. Communicative Content

One definition of communication is to make known. To make known solely by visual symbols is not new. The cave painters left a record of their lifestyle. Painters and sculptors have produced an impressive visual record. Silent pictures entertained and educated many Americans prior to "talkies." Even the supersalesmanship of modern advertising rests as much on visual symbols as it does on the hyperbole of the well turned phrase.

Our reaction to visual symbols is a matter of cultural training. Each day we are bombarded by sights which have communicative content. The photographer therefore can rely on this resource to create pictures which can effectively communicate without reliance on words.

603. Given two ideas to communicate photographically and several possible compositions for each, select the one that would best communicate each idea.

To communicate as a photographer you have to have a clear view of the principles of communication. Communication requires a sender, the medium of communication, and the receiver. You are the sender, your medium of communication is the photograph, and the receiver is the viewer of your work. To be an effective communicator you need to have a clear understanding of the receiver. You must communicate in a way that will be understood. For example, if you speak only English and you are trying to talk to a man who only understands German, there will be little effective verbal communication between the two of you. The same can happen in your photography. If you use visual symbols the viewer does not understand, your message may not get through. Suppose you are doing a picture story on religion in contemporary American life. Your lead shot shows a Shinto altar. The image may have little impact on an audience that relates only with Christian symbols, such as a cross.

The background, education, tastes, and interests of your audience are keys to success. The activities of the various sections and squadrons, family services, flying club activities, and recreational services, while not having universal appeal, may all be of vital interest to people at your base. A silhouette of the tail of a C-5A, the Thunderbirds in formation, a security policeman with his dog, the base commander throwing out the first ball at a little league game, and opening of the base swimming pool will communicate to your audience without the need for extensive captions or copy.

Communicative Elements. The elements you can use to communicate with are people, props, backgrounds, and lighting. Let us briefly consider each one of these.

People. Women, children, and men, different ages, states of dress, and expressions will evoke different feelings in the viewer. A tight shot of a pilot wearing his helmet, face mask, and oxygen gear evokes a different feeling than a shot of a pretty girl by a swimming pool.

Props. Cameras, knives, tools, rifles, food, airplanes, automobiles, flags, etc., can be used to leave distinct feelings. For example, an airman holding a wrench may appear different than if he holds a rifle.

Background. A rundown tenement house, modern buildings, a hospital, the flight line, mountain lakes, or a farm all conjure up different moods in each of us. The choice of environment in which the subject is placed is most important.

Lighting. Harsh contrast lighting gives a much harder edge to a picture than lower contrast lighting. It is important that the lighting should fit the mood of the picture.

Consider carefully each picture element and its communicative impact on the viewer. Add, subtract, or rearrange picture elements so that your message comes through loud and clear without distractions. (Does fig. 1-24 communicate to you?)

Exercises (603):

1. Which one of the following would bring out the idea of pride?
   a. Three airmen standing outside the BX.

   b. An airman receiving an award with his family looking on.

   c. An airman asleep on the grass.

2. Which picture arrangement would best emphasize childhood joy?
   a. A child eating his dinner.

   b. A child receiving a shot.

   c. A child opening Christmas presents.

Reproduction Photography

THE TERM "COPYING," as used in photography, means the photographic reproduction of another photograph, drawing, map, chart, or similar flat-plane object. Reproductions of this type have a number of uses. Consider several examples. If a negative is lost or unavailable, a duplicate may be made by copying a print made from the original negative. Valuable documents, if used constantly, soon become worn and illegible; however, by making reproductions through the process of copying, you can preserve the original. On some occasions, it may be desirable to reproduce the subject at a different scale or size; this change, too, can be effected by copying. Again, in some instances, a great quantity of prints from a single negative is sometimes requested with a deadline for delivery. In such cases, duplicate negatives may be made and given to as many printing teams as necessary in order to complete the work in the stipulated time. On other occasions, copying may be used to improve a photographic print. For instance, stains and blemishes clearly detract from the quality of the print. If, however, such a stain or blemish is transparent or translucent, it may be toned down by using a filter that is deeper than the color of the stain.

Every picture which you see in a newspaper, book, or magazine has been copied at least once. Banks make photographic records of checks received. Entire libraries are copied on film that occupies a tiny fraction of the space required for the books. Copying is thus of great importance. To be successful, such copying requires careful work. The problem of copying is complicated by the great variation in the nature of the originals to be reproduced and by the varying conditions under which the work is to be done.

In this chapter we will discuss copying reflective subjects, making scale change provisions, duplicating transparent material, and using specialized copy procedures.

NOTE: To add to your understanding of this chapter you should review the use of copy cameras and duplicating cameras (Volume 2, Chapter 3).

2-1. Copy Reflective Subjects

Subjects to be copied are broadly categorized in two ways: reflective or transparent. Reflective subjects, like photographs, paintings, schematics, and maps, are very common copy subjects. Reflective subjects are so identified because they are copied by reflected light rather than light passing through the subject as is the case with transparencies (e.g., slide copying). Proper copying of reflective subjects (or transparencies) is only achieved by proper lighting, camera operation, filter selection, exposure, and appropriate film/developer combinations. We have discussed camera operation and filters, and we will review particular copy exposure problems in the section on scale changes, so now let us take up the other topics as they relate to copy work.

604. Complete statements related to the correct lighting of reflective copy subjects.

Copy Lighting. You can use practically any type of lighting source when making copies; included are ordinary tungsten lamps, photoflood lamps, flash, fluorescent tubes, daylight, quartz iodine, and mercury vapor systems. Regardless of the type of lights used, the basic requirement for copy lighting is even illumination. Uneven lighting will result in negatives with uneven density, and the production of uniform prints that match a good original print will be impossible. An easy check for evenness of illumination is to place the end of a ruler or similar opaque object against the center of the subject at a slight angle. (Be careful that you do not get your body in the path of the illumination.) Balancing the shadows on each side of the ruler enables you to control the evenness of the intensity. Move either light, as necessary, to equalize the lighting.

Subject material. An important consideration in light-positioning is the subject material. For smooth, glossy surfaces, the lights will provide the best illumination with the least amount of reflection when placed at an angle of approximately 45° to the subject. The lights should be moved more nearly parallel for rough surfaced material. An angle of 75° will minimize texture detail and help assure higher quality reproduction. (See fig. 2-1.)

Reflection control. Two conditions generally cause reflections in copy work. One is reflection of the light source; the other is reflections over the entire surface of the copy subject.

Reflections of the light source are caused by light reflections from the camera stand, lensboard, or any other equally shiny object around the copying setup. These reflections usually occur when you are copying glass-covered paintings, glossy photographs, and other smooth surface objects.

The easiest way to eliminate this type of reflection, if changing the position of the lights does not help, is to use a black cloth or sheet of hardboard painted dull black as a shield. By cutting a hole (the size of the lens) in the center of the board and by placing the board over the lens, you can usually eliminate this type of reflection. You may also use a sunshade to aid in eliminating stray light rays and reflections.

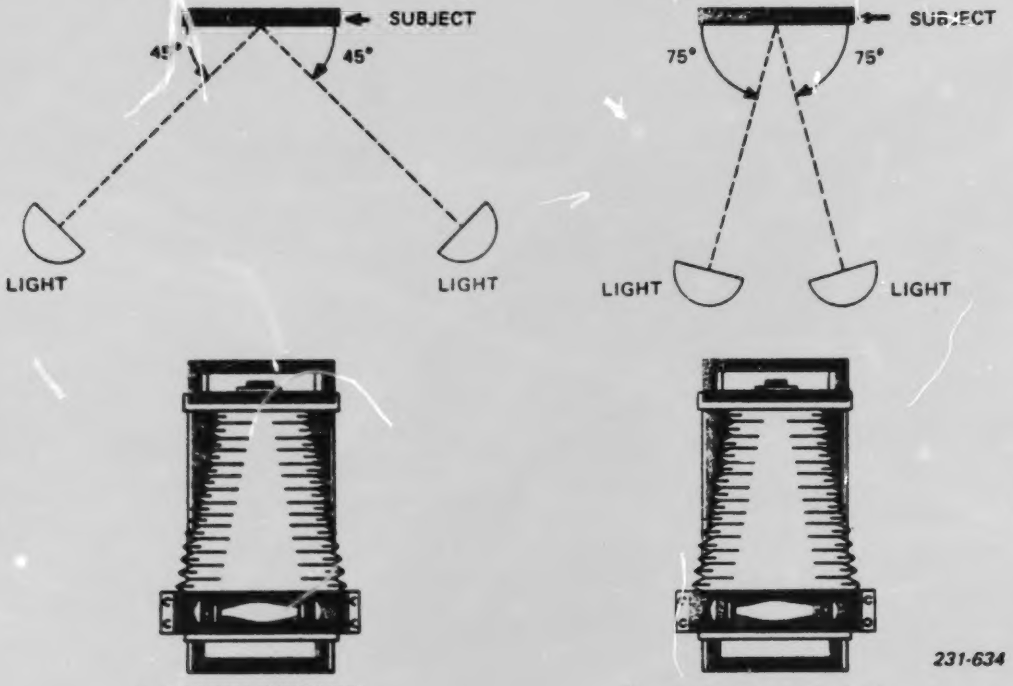
Reflections over the entire surface occur with rough, scratched, crumpled paper prints or paintings with strong brush marks, canvas textures, or cracks, etc. These reflections occur because each high spot in the surface of the original causes a small specular reflection of the light source. Such small reflections cover the surface of the copy with a haze of light which destroys contrast and results in a flat, muddy image. The two methods to subdue or eliminate surface reflections are (1) bounce lighting and (2) polarized lighting.

Bounce lighting may be used as follows. If the ceiling of the copy room is low enough, direct two lamps upward so that the light bounces off the ceiling and spreads a soft, diffused light over the original. If the ceiling is too high, it may be possible for you to use a large white board positioned horizontally over the lights to reflect the light to the subject.

Polarized lighting is a little more complicated than bounce lighting. For one thing, placing a polarizing filter over the lens alone makes little, if any, improvement because the lens axis is at right angles to the subject's surface. But by using a polarized light system, most reflections can be eliminated. To use this system, place a polarizing screen over each lamp and also place a polarizing filter over the lens. By rotating the filter, you can reduce or eliminate all the reflections.

Exercise (604):

1. Complete the following statements on copy lighting.
   a. __________ type of lighting source can be used in copy work.



A. SMOOTH SURFACES

B. ROUGH SURFACES

Figure 2-1. Positioning lamps.

b. To be effective, copy lighting must be ____ .

c. With glossy surfaces, the lights should be at ______degrees to the subject.

d. Using a lenshade can cut down ______ source reflections.

e. Reflections off a very rough surface can be cut down by using either _________ or________ lighting.

605. Identify characteristics, problems, and techniques associated with the copying of different types of reflective subjects.

Reflective Copy Subjects. Let us discuss specific problems of copying different types of reflective subjects.

Black-and-white line originals. A number of varied documents and subjects may be found under this heading. For example, you may be required to copy such things as (1) maps that are printed in black and white, (2) musical scores to be distributed among Air Force band members, and (3) certain published procedures, such as processing instructions for a particular machine, to be used as training aids. It is also possible that you may, on occasion, (4) copy letters, such as letters of commendation, to be distributed among various personnel at your base.

Generally speaking, a line original has but two tones—black (or a dark shade of gray) and white (or a very light shade of gray). As far as contrast is concerned, these two tones should be separated as much as possible. The net result is a high contrast negative; and when combined with printing on a high contrast paper, the high contrast of the original is maintained. Remember, under these high contrast conditions, film latitude is very low and the exposure is critical. Consequently, if you miss the exposure, you are taking a chance on filling in or obliterating fine lines. To avoid this, you should allow ample exposure but not overexposure of the film.

If the black-and-white material is printed on just one side, it may be backed with white paper to increase the contrast. This is especially true if the original had been printed on rather thin paper, in which case the dark color of the easel may shine through. If the material being copied has been printed on both sides, such as you might find if you were copying a page from a magazine, the ink from the reverse side may possibly show through. Should you encounter such a situation, it would be wise to back the original being copied with black paper in order to avoid recording the material on the reverse side.

Colored line originals. In general, the technique of copying colored line originals onto black-and-white film is essentially the same technique as that used for copying black-and-white material. Among the colored line subjects which you may be required to copy are maps that have been printed in several colors in order to define different terrain features; drawings that have been printed in colored ink, with the color identifying various mechanical features; and blue-prints. The usual problem is to obtain the greatest contrast between the line and the background materials. Typically, it is best to use panchromatic film for this type of copying, since filters are most frequently used to obtain the high degree of contrast that is necessary. For example, when copying a blueprint maximum contrast can be obtained by using a red filter which will cause the blue background of the diagram to appear clear on the negative.

Black-and-white continuous tone originals. The most common black-and-white, continuous tone original that you will be required to copy will undoubtedly be a photographic print. A good copy negative made from such a print should closely resemble the original negative. It should have the same gradation in tones as the original. Accurate rendition of this type of original requires the use of a film with a medium contrast, as well as the correct exposure and development. Obviously, if you underexpose a negative in a camera, you lose shadow detail. The same is true in copying. By the same reasoning, overexposure in either situation causes a blocking of highlight detail.

Very often you may be required to copy old photographs that are wrinkled or creased. These wrinkles or creases generally cause reflections. The print may be flattened out by pressing the print under a piece of heavy glass. You will then have to use the appropriate lighting to reduce reflections off the glass surface.

Ordinarily, if the print is badly soiled, it should be cleaned before copying. If, however, it is a valuable print, you should obtain the best possible copy reproduction before attempting any cleaning. Of course, if damage to the old original is considerable, you obtain the best possible copy, then retouch the resulting print and recopy it.

Stained prints can be copied on panchromatic film. When you do this, use a filter as close as possible to the color of the stain. In fact, for best results, the color of the filter you use should be somewhat deeper than the color of the stain. For example, if a print has a yellow stain, it should be copied on panchromatic film in conjunction with a deep yellow filter.

In contrast with stained prints, copying faded prints is different. For one thing, if the image has turned yellow with age, you must restore its original brilliance. Consequently, you should use a filter which is opposite in color to the faded image. For example, if the image has turned yellowish-brown, you can copy the print on panchromatic film with a blue filter. In such a case, you may find that rather than using panchromatic film, it is simpler to use blue-sensitive film without a filter.

Color continuous tone. Various types of color continuous tone originals may be successfully copied onto black and white. Examples of these include water or oil color paintings, color photographic prints or magazine illustrations. Typically, you would use panchromatic film of moderate contrast. Filtration may be necessary if you need to achieve contrastier tonal separations.

A soiled color print may be very difficult to clean because of the nature of the dyes that make up the image. You may find that the best way is to copy the soiled print and then retouch the print made from the copy negative. The retouched print then can be copied.

Stained color prints can be copied through the appropriate filter. The filter should be darker than the stain color. One problem is that the filter will affect the other colors of the print.

Exercises (605):

1. Match the copy subject in column A with the appropriate category in column B.

Column A	*Column B*
1. Musical scores	a. Color continuous tone
2. Color schematic	b. Black-and-white line
3. Black-and-white scenic photograph	c. Black-and-white continuous tone
4. Oil painting	d. Color line

2. What type of black-and-white film should be used to copy a line drawing? Why?

3. If you have a print that has a green stain, what color filter should you use?

4. If you are copying a page from a magazine, what precaution should you take?

5. What color of filter should you use when copying a yellow faded print?

606. Select the appropriate film/developer combination for different types of copy subjects.

Film/Developer Combinations for Copy Work. The variety of subjects to be copied are such that no one film can satisfactorily reproduce all of them. Consequently, the selection of a film/developer combination should be governed primarily by the classification of the copy subject. Since the characteristics of film emulsions vary widely, it is important for you to know these differences so that you can choose the proper film for the desired results.

Films designed for copy and reproduction are generally slower than conventional films for general everyday usage. This reduced sensitivity provides good resolving power, maximum definition of subject matter, and greater control of contrast. However, the exposure latitude is shortened and this creates the need for increased exposure accuracy. In fact, the slower photomechanical films, such as Type VIII Class E, become most critical.

Even the manufacturers, realizing the various sources of illumination, omit any specific film speed rating for Type VII films. Only a suggested exposure is included with the data charts. Photomechanical film is primarily designed for exactness in image-scale reproduction and consists of a thin base with a very low percentage of shrinkage or stretch during processing. Most frequently used is Class E having an orthochromatic emulsion, which can be handled under red safelights for identification because the familiar code notches are not included. Type VIII, Class H, film is available when panchromatic emulsions are essential.

To obtain the maximum contrast that these photomechanical films are capable of producing, develop them in a fine line developer. This solution comes in a two-package "A" and "B" container. Each package of powdered chemicals must be thoroughly dissolved and stored in well-stoppered containers. The working solution consists of equal parts of "A" and "B," which tends to exhaust rapidly due to its high alkaline content, and should be used shortly after preparation is completed. Agitation is recommended during the first 20 seconds and range of average development is 2 to 4 minutes. Should a substitute solution such as D-19 be used, increase exposure about 25%.

The primary guideline of consideration is the type of original to be copied. The classifications itemized in table 2-1 provide an average guide: (1) orthochromatic emulsions, class E, or high-contrast E-1 and gravure for black-and-white subjects, (2) panchromatic emulsions, class H, for high-contrast, and class A for subjects containing all colors or continuous tones of intermediate shades and densities; (3) type VII for scale stability and mechanical capabilities such as engraving; (4) type V is generally applied to certain photographic printing requirements in production of copy negatives.

TABLE 2-1
FILM/DEVELOPER COMBINATIONS USED IN COPY PHOTOGRAPHY

FILM DESCRIPTION	FILM CLASSIFICATION TYPE	CLASS	SUBJECT CLASSIFICATION	DEVELOPER	RATIO OF DILUTION	TIME 68°F
PROCESS PANCHROMATIC	V	H	BLACK AND WHITE LINE DRAWINGS	D-19 (AF 1)	NONE	6 MIN
PROCESS ORTHOCHROMATIC	V	E		D-19	NONE	6 MIN
PHOTOMECHANICAL PANCHROMATIC	VII	H		FINELINE "A" & "B"	NONE	2-4 MIN
PHOTOMECHANICAL ORTHOCHROMATIC	VII	E		"A" & "B" FINELINE	NONE	2-4 MIN
PHOTOMECHANICAL PANCHROMATIC	VII	H	COLOR LINE DRAWINGS	FINELINE "A" & "B"	NONE	2-4 MIN
PROCESS PANCHROMATIC	V	H		D-19 (AF 1)	NONE	6 MIN
COMMERCIAL ORTHO	V	E-1	BLACK & WHITE CONTINUOUS TONE	DK-50 (AF 2)	1-2	6 MIN
MED-CONTRAST PANCHROMATIC	V	A		DK-50 (AF-2)	1-1	5 MIN
MED-CONTRAST PANCHROMATIC	V	A	COLOR CONTINUOUS TONE	DK-50 (AF-2)	1-2	6 MIN
MED-CONTRAST ORTHOCHROMATIC	GRAVURE		CONTINUOUS & HALF-TONE B & W	DK-50 (AF 2)	1-2	6 MIN

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Perhaps the one film which could be classed as general-purpose for the majority of routine copy in photography is commercial ortho (type V, class E-1). This emulsion is closely related to Gravure film and provides fine detail plus delicate tone gradations. Landscapes, portraits, machine illustrations, and mechanical parts illustrated in black and white are typical subjects for copy using commercial ortho. Ortho is of course not suitable for color copy as it is insensitive to red.

Another popular copy film is panchromatic class A. Characteristics of medium contrast, speed, and grain coupled with good resolving power make it suitable for all black-and-white and color continuous tone subjects.

Exercise (606):

1. Match the correct film/developer combination listed in column A with the appropriate copy subject listed in column B. Be sure not to use a particular combination more than once.

Column A	*Column B*
1. VH/Fineline A&B	a. Black-and-white portrait
2. VA/D-19	b. Oil painting
3. VE-1/DK-50	c. Blueprint

Column A	*Column B*
4. VIIE/D-19	d. Black-and-white schematic
5. VE/D-19	
6. Gravure/Fineline A&B	
7. VH/D-19	
8. VIIA/Fineline A&B	
9. VA/DK-50	
10. VIIH/D-19	

2-2. Scale Change Provisions

The scale of a reproduction is the ratio between any linear dimension of the copy and the related dimension of the original. For example, if an 8 x 10 picture is reproduced at half scale (50-percent reduction), the reproduced dimensions on the negative are 4 x 5. As you will be required to do copy work at other than one to one (100-percent), you will need to know how to make appropriate scale changes. In addition, scale changes will involve changes in exposure which you should be well aware of.

NOTE: Fortunately, most copy cameras have calibrated scales which help the operator to achieve proper reproduction ratios without mathematical calculations.

607. Solve a series of scale change and copy exposure problems.

The focal length of the lens, the bellows extension, and the distance from the subject to the lens are all interrelated when you are trying to achieve proper scale. These relationships can be easily established by two simple formulas:

Bellows extension = FL × (scale + 1)
Subject distance = BE + scale

Now, let us use these two formulas to solve two sample problems. Find the bellows extension and subject distance for a 12-inch focal length lens at two different scales, as shown by the following:

Scale 1 to 2 (50%):
    Bellows extension = 12 × (1/2 + 1) = 18 inches
    Subject distance = 18 + 1/2 = 36 inches

Scale 1 to 1 (100%):
    Bellows extension = 12 × (1 + 1) = 24 inches
    Subject distance = 24 + 1 = 24 inches

As these examples show, to accomplish different ratios in reproduction, you must vary the bellows extension. As the bellows extension is increased the effective focal length of the lens is also increased. This change in "focal length" makes the calibrated aperture values inaccurate. You, therefore, have to calculate a bellows extension factor which is then used to increase exposure so you will not be underexposed. The following formula is used to compute this factor:

$$\frac{\text{Bellows extension}^2}{\text{Focal length}^2} = \text{bellows extension factor}$$

Example:
Bellows extension is 12 inches.
Focal length is 6 inches.

$$\frac{12^2}{6^2} = \frac{144}{36} = \frac{4}{1} = 4 \text{ (bellows extension factor)}$$

Once the bellows extension factor has been calculated, you then multiply that times your conventional exposure (determined by a light meter, etc). For example, if the conventional exposure was 1/2 second at f/11 and your bellows extension is 4, the new exposure would be 2 seconds (4 × 1/2) at f/11.

NOTE: Long exposure times are not a problem with copy cameras as they are normally very rigid. If, however, there is a reciprocity failure problem, you then can change the aperture setting as appropriate so that the exposure time is not too long.

Exercises (607):

1. A 200-percent enlargement of a 3″ x 4″ photograph would give you what final dimensions?

2. A 25-percent copy of a 4″ x 5″ painting would give you what dimensions?

3. Assume you are using an 8-inch focal length lens and you are making a 1-to-1 copy. What will be the bellows extension and subject distance? What will be the bellows extension factor? What will be your new shutter speed if the conventional exposure is f/8 at 1/8 of a second?

4. Suppose you are using a 12-inch focal length lens and you are making a 2-to-1 copy. Calculate the bellows extension and subject distance, the bellows extension factor, and your new shutter speed if the conventional exposure is f/11 at 1/2 second.

2-3. Duplicating Transparent Material

In the Air Force there is an ever increasing requirement for the production of slides for briefings of VIPs, orientation of new personnel, and training aids. We can safely say that any subject that can be photographed or copied can be readily presented as a slide. The primary function of any material presented in slide form is educational and usually supports a lecture or demonstration. The combination of audio-visual communication is used in nearly every learning situation. It has been proved that the education value of any lecture is enhanced by the inclusion of graphs, charts, maps, or original scenes in slide form.

Duplicating of 35mm slides will probably be your main transparency copying assignment. In another volume of this course we discussed the operation of the Repronar, which is specifically designed for slide copying. Other similar units are available, and one can use almost any 35mm reflex camera to do slide copying with the proper adapters. In this section we will briefly talk about the films and corrective techniques you can use in slide duplication when using a unit like the Repronar.

608. Identify as true or false statements related to the duplication of slides.

Films Used for Slide Production. Slow speed, fine grain, reversal color film is the mainstay for slide production. Many manufacturers produce color film that is specifically designed for slide duplication. The use of color film is even suitable when the subject is black and white. This is particularly true when you do not have reversal black-and-white film capability.

One of the difficulties encountered in duplicating transparencies is the tendency of the copy to be contrastier than the original. The contrastier duplicate has washed out highlights and blocked up shadows, both lacking in detail that was present in the original. This can be corrected by controlling exposure and development.

Corrections During Duplicating. First, when copying slides with a tool like the Repronar, it is a good idea to remove the slide from the slide mount. This will insure that you can get a 1 to 1 copy. If you copy the slide in the mount, part of the original image is cut off by the mount, and your duplicate image will further reduce the image by its mount. This can be critical if you are copying slides that have titles that could be cut off.

It is possible to correct for improper exposure, composition, or color balance when copying. Composition can be corrected through enlarging the image, thereby cutting off some distracting elements. Regrettably, as you enlarge there will be more "grain" in the duplicate. Color correction or exaggeration can be achieved through the use of filters designed for color photography. In fact, for exact color fidelity, a filter may be needed, depending on the type of copy film that is being used and the Kelvin temperature of the exposing light source. (By studying Chapter 5 of this volume you will have a better understanding of how to use color films.)

Under or overexposed slides can be corrected. When using the Repronar to copy an underexposed slide so that it will be underexposed in the duplicate, you should open one f/stop for each stop of underexposure. To correct (to achieve normal density) open two f/stops for each apparent stop of underexposure. Best results are achieved by bracketing your exposure. (The procedures used for the Repronar may not apply to other types of equipment. As always, read your equipment instructions for best results.) To copy an overexposed original, the diaphragm should be closed down one stop for each apparent f/stop of overexposure. To correct (to achieve normal density instead of an overexposed copy), the diaphragm must be closed one additional f/stop for each apparent f/stop of overexposure.

NOTE: The correct density for any slide is often a matter of opinion. It may be affected by the type of composition, the particular feeling you want to convey, and the type of projection equipment you are using. This last point is quite important. Some projection systems are quite powerful and a slide that might appear to be normal when viewed on a light table may appear overexposed when projected. Conversely, there are some audio-visual equipment systems that have weak projector outputs and the slide may appear underexposed. It is therefore important to understand how the requester will use the slide.

Duplicating slides can also permit many creative effects. For example, it is possible to make multiple images by successively copying more than one onto the film. In this manner you can also add titles or other graphic work. You can, as was mentioned before, use filtration to alter the color balance to achieve distinctive effects.

Slides are extensively used for the visual element in briefings and training. Therefore, you should practice shooting and duplicating slides, as these are vital parts of any base photo lab operation.

Exercise (608):

1. Identify whether each of the following statements regarding the duplicating of transparencies is true or false.
   a. It is best to use high-speed color film when duplicating a slide. True or False

   b. If you copy a mounted slide, you will be able to get a 1 to 1 image. True or False

   c. You can correct for color balance when you duplicate. True or False

d. It is possible to add titles to your slides. True or False

e. To correct for a two-stop underexposed slide when you are working with the Repronar, you must open up four stops. True or False

2-4. Use Specialized Copy Procedures

There are a number of specialized copy procedures which you may come in contact with during your photographic career. These may include microfilming and use of photocopiers such as a Xerox machine. In this same vein is the MP-4 multipurpose land camera. This versatile tool can be used in a variety of copy jobs and as an enlarger or a view camera (one without

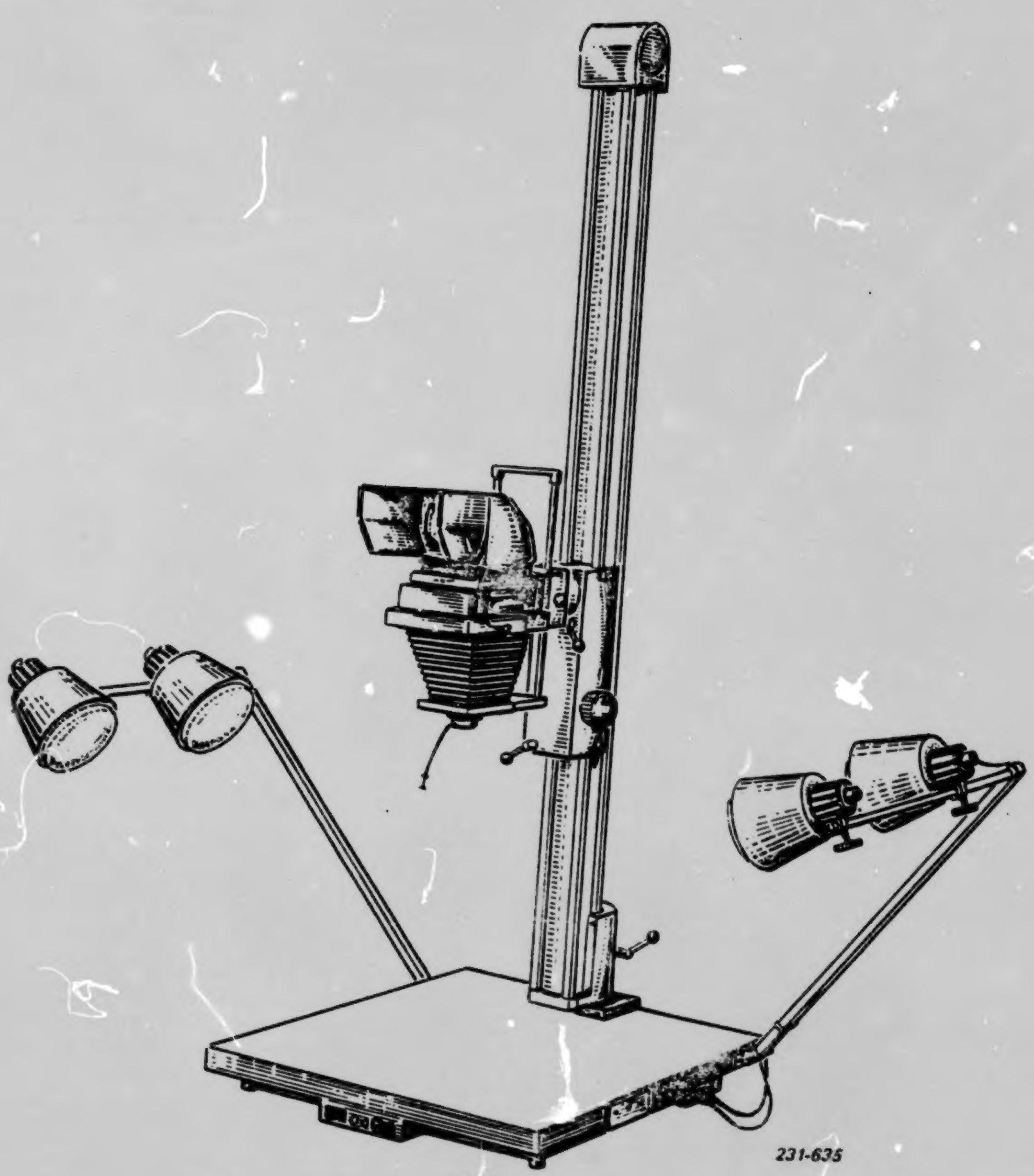

Figure 2-2. MP-4 copy camera.

swings and tilts). As you may well be able to use this camera system or its predecessor, the MP-3, we will briefly discuss its possibilities as an example of a specialized copy process.

609. Complete statements on the capabilities and operation of the MP-4.

The MP-4 is a copy, photomacrographic and photomicrographic recording system. (See fig. 2-2.) It is copy stand mounted with eye-level reflex viewing. With interchangeable Polaroid roll, pack, and 4 x 5 film holders, there is a choice of 14 different types of Polaroid films. In addition, adapters and cut film holders make it possible to use conventional photographic films ranging from 35mm through 4 x 5.

Four flat field copy lenses are available, ranging from a 35mm macro through an all-purpose 135mm lens. This makes it possible to meet any type of copy or enlargement requirement. However, only the 105mm and 135mm lenses focus to infinity, making these the only choices when the MP-4 is used as a conventional, tripod-mounted camera. All the lenses are color corrected and are barrel mounted for quick change in the shutter.

There are three shutters which are available. The basic one has a Copal self-cocking shutter with speeds from one second to 1/125 of a second, plus "B" for time exposure and "X" for flash synchronization. Connected to the shutter is a preview cable. The cable opens the shutter for viewing and focusing.

The MP-4 comes mounted to a column which is attached to a laminated baseboard. The camera can be tilted through 360° and locked in any position. The camera is removable for use on a tripod as a view camera. On the XLR model (model with the most features), the column can be rotated completely around its base permitting pictures to be taken in any direction or at any angle. Other Polaroid and conventional cameras can be attached to the column using the universal camera mount.

The lighting assembly consists of four 150-watt reflector flood lamps attached in pairs on each side of the base. The lamps are adjustable to insure even lighting.

The accessory list is extensive so that the MP-4 can be adapted to a number of assignments. These accessories include a condenser enlarger head to convert the PM-4 to a standard 4 x 5 enlarger; glass negative carriers for negatives from 35mm to 4 x 5; different types of focus screens, film holders, and camera heads; tripod adapter; microscope adapter; and a macro extension for closeups, etc.

Operation is pretty straightforward. The subject to be copied is laid flat on the copyboard. Viewing through the reflex hood you can focus the image within the format indicators outlined on the focusing screen or ground glass. (The image will, however, appear reversed from left to right.) The image size is controlled by raising or lowering the camera just as you would do when enlarging. By adjusting the bellows you can achieve fine focusing. Once the image is focused and is of the proper size, you can then check the lighting. The lighting should be even. (In adjusting the lights, you may set vibrations in motion. If this is the case, wait about 30 seconds for the unit to stabilize.) Once everything is set you can put the film holder into position. You can determine the exposure by taking a reflective light meter reading and making adjustments for copy ratios and any filters. (Remember, with Polaroid film it is so easy to run tests to determine correct exposure!) Set the aperture and the shutter speed. Make your exposure. Very easy, and the results are of top quality.

Exercise (609):

1. Complete statements on the capabilities and operation of the MP-4.
   a. The MP-4 can handle film sizes up to ______ .

   b. There are ______ copy lenses available for use on the MP-4.

   c. The __________ and __________ lenses are suitable when the MP-4 is used in the conventional camera mode.

   d. The basic MP-4 shutter is __________ and has shutter speeds ranging from ______________ __________ through __________ .

   e. There are __________ __________ watt flood lamps to provide even lighting.

   f. Viewing is through a __________ hood.

   g. The MP-4 head can be rotated through ______ degrees.

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Photographic Assignments

A PHOTOGRAPHIC WORK order simply states a desired result that must be provided. Your supervisor's task is to determine the course of action to be followed to give the user the best quality work available at the least cost to the Air Force. As you can understand, this requires planning for the entire task.

Each photographic facility has its own set of conditions, such as personnel, workload, and equipment. Photography is not a field where there is only one set method to accomplish each task. Therefore, many factors must be considered in determining how a job is to be carried out.

It is important that when you are called upon to carry out a mission, you are aware of what is required. In this way you can apply the skills you are mastering to get the necessary results. In this chapter we will discuss many of the various types of missions you may be assigned to do and some of the basic techniques you may want to use.

3-1. Apply Public Relations Principles to Photographic Assignments

Public relations in Air Force photography involves two concepts: first, the use of photographs to gain the public's active participation and support of Air Force programs; and second, your relations with the public when on assignment. The first concept you will learn as you carry out assignments for the information office. The second concept is one which applies to any mission you will do. It is, therefore, the most important and one you can start applying right now.

610. State principles and techniques of public relations which are used during a photographic assignment.

Human Relations, the Basis of Public Relations. To function successfully as a photographer, you must have more than a general knowledge of photography. You must be the complete master of your tools and techniques; and in addition, you must understand something of human relations. It is not enough for you merely to be polite and courteous. To photograph the complexities of people in everyday life, you should understand what motivates them, what shapes their attitudes, or simply, "what makes people tick."

For the sake of discussion, we can arbitrarily state that individual characteristics of people come from four sources. They are biological-genetic, cultural, sociological-economic, and psychological.

Every person is, in a sense, a complex arrangement of the above factors; and if we understand them, we may be able to understand ourselves or, more importantly, the people who come before our lenses. Remember, these characteristics are interrelated and are separate in this discussion only for the sake of clarity. Let us look at each in turn.

Biological-genetic factors. In this category, we must consider race, sex, stature, physical assets or liabilities, and intelligence.

The intelligence of an individual develops and changes with his environment, even though there is a biological-genetic basis for the intelligence a person possesses. One theory suggests three classifications of intelligence: mechanical, social, and abstract. As a photographer, your mechanical intelligence allows you to manipulate your equipment; your social intelligence allows you to understand and deal wisely with people; and your abstract intelligence provides you with the ability to handle symbols, ideas, words, numbers, formulas, and scientific principles.

The second factor, sex, is a strong biological and psychological drive which affects each of us. It has also been used in a discriminatory sense. Women in America, for example, have been stereotyped in homemaking and child-rearing roles. Today, more and more women are asserting their rightful individuality so that "male" and "female" roles are no longer so rigid. In the Air Force women are serving in almost all of the career fields. It would, therefore, be in poor taste to photograph a woman serving in the Air Force simply as a "sex symbol."

The third and final factor is race. Race is often confused with nationality. People speak of the "English," "German," or the "Italian" race. But the people of these countries are descended from many races. They are properly called peoples, for each group has its own language, culture, traditions, and political ideals. This does not make them races. Races are generally distinguished by outward physical appearances, such as skin color, hair texture, stature, and facial features. Race has been cruelly used by ignorant people as a basis of discrimination.

Cultural factors. Cultural factors include customs, manners, modes, values, symbolism, symbolic behavior, language, laws, and judgments. All of these traits, habits, and characteristics which separate man from the other animals are learned by man as part of his society. Each society has its own hierarcny of values. Your values may be quite different from those of other people. You must respect the values of other people even if you don't share them.

Sociological-economic factors. Each of us is a member of a group, or of many groups. We identify groups by such vague terms as "middle class," "blue collar," "jet set," "disadvantaged," or any other stratified ranking or position in our society. Often these rankings are based on job type or social standing. Each group normally demands that (1) we exhibit the traits and characteristics of the group in question and (2) be accepted by other members of the group. Unless these two conditions are fulfilled, we do not belong to the group. (You are fulfilling these two conditions as you adapt to Air Force life.) Understanding what group your photographic subject belongs to may help you in understanding him.

Psychological factors. This is the realm of the individual. How does he cope with reality? What are his defense mechanisms? Does he project his fears to others? What is his opinion of himself in relation to the world around him? Above all, how well does he adjust? The more you know about your subject the better able you will be to accurately portray him or her.

"What does this have to do with photography?" When you, the working photographer, come into contact with people, you are involved with what might be called the "situation." If you could predict all your subject's personality "hang ups," you could predict how your subject would react in a given situation. You have to remember that you, too, have your own "hang ups" as well, and that they are also an integral part of a "situation." Out of this situation, something must happen, and these are the "consequences." In our case, the consequences must be good pictures. How good these pictures are is the direct result of how well you control the situation.

To help you control the situation, you must be aware of another aspect of human behavior. Sociologists and psychologists designate the various things we do in certain situations as role play. We all play many and varying roles in life, many of them simultaneously. For example, the base commander may also be a pilot, husband, father, and sports enthusiast. In each case his role is different and the degree of formality and pictorial content required in each situation would be different.

Only experience can give you the sensitivity you need to effectively function as a creative photographer. Knowledge of what motivates people, as individuals and as members of complex groups, is just as much your stock-in-trade as your camera and film. Too often, too many of us spend endless hours refining camera handling techniques, time that could perhaps be spent more profitably developing the confidence and genuine interest to establish rapport with people.

We, therefore, cannot hope to give you guidance for all of the situations that could possibly arise. But, we can give you some general guidelines that may help you in the future. The "Golden Rule" is just as valid today as when it was first conceived. Common courtesy, proper military bearing and appearance, and efficient camera and lighting techniques can go a long way in giving you situational control. Respect your subject and your subject will respect you. Be considerate of his likes and dislikes and he will be considerate of yours. Be compassionate and understanding and you will be understood. Have confidence in yourself and your equipment and your subject will have confidence in you. You should be familiar with all of the general rules of military behavior and conduct. If overseas or in a strange environment, take the time to learn the local customs and social graces. They pave the way to better photographs. All of this can be summed up in two words—BE PROFESSIONAL.

Exercises (610):

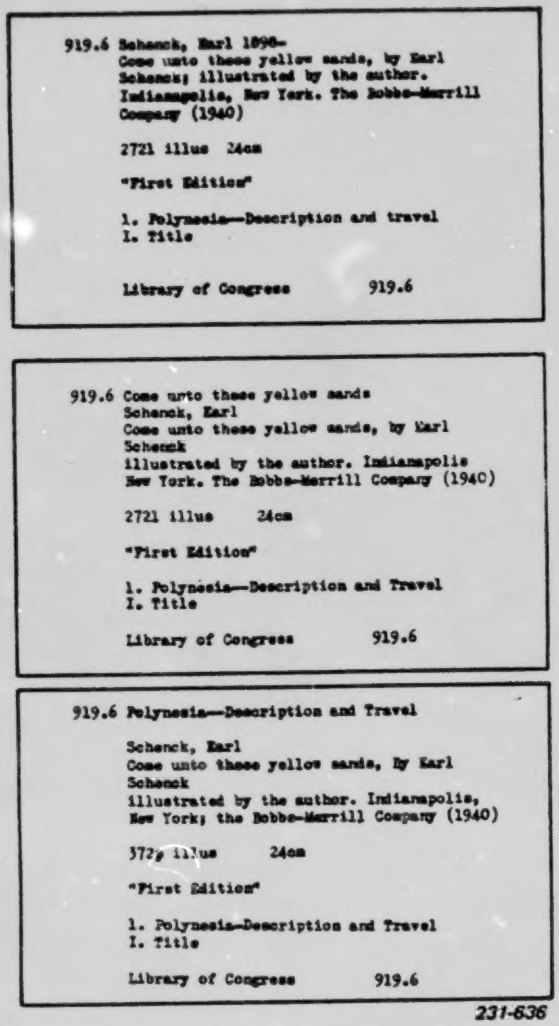
1. Individual characteristics are molded from what four sources?

2. What are two factors which may determine a person's intelligence?

3. What is the difference between race and nationality?

4. What two conditions must be fulfilled for you to belong to a group?

5. Why does it pay to be professional?



919.6 Schenck, Earl 1890-
Come unto these yellow sands, by Earl
Schenck; illustrated by the author.
Indianapolis, New York. The Bobbs-Merrill
Company (1940)

2721 illus 24cm

"First Edition"

1. Polynesia—Description and travel
I. Title

Library of Congress 919.6

919.6 Come urto these yellow sands
Schenck, Earl
Come unto these yellow sands, by Earl
Schenck
illustrated by the author. Indianapolis
New York. The Bobbs-Merrill Company (1940)

2721 illus 24cm

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I. Title

Library of Congress 919.6

919.6 Polynesia—Description and Travel

Schenck, Earl
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Schenck
illustrated by the author. Indianapolis,
New York; the Bobbs-Merrill Company (1940)

372p illus 24cm

"First Edition"

1. Polynesia—Description and Travel
I. Title

Library of Congress 919.6

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Figure 3-1. Author, title, and subject cards.

3-2. Perform Photographic Assignment Research

Prior to rushing out on a camera assignment, you should have a clear idea of what is required. Only in this way can you make an intelligent choice of camera equipment, film, flash or other lighting equipment, and the many accessories you may need to fulfill the assignment. By applying the "5 Ws" of journalism, you will have the necessary information.

611. Identify and explain the 5Ws of journalism.

In almost every news story the reporter wants to find out the who, what, when, where, and why of the story. You can apply the same principle prior to going out on a job. Most of the information will come from the work order. From it you should be able to determine: who is taking part; what will be taking place; when and where it will be held and why (reason for or significance of the event). If you cannot get this information from the work order, you should contact your supervisor or the requester to make clear these very basic aspects of the assignment. Once the basic factors of the assignment are made clear, you can organize an equipment check list and a plan for shooting. In this way you will better insure mission success.

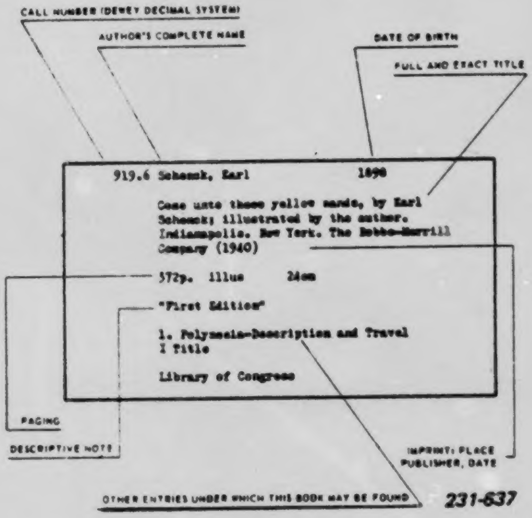
Exercise (611):

1. Identify and briefly explain the 5Ws of journalism that can be applied to assignment research.

612. Complete statements on the use of the library.

To carry out a variety of assignments, today's photographer must be a well-informed individual. You have to know what is happening in areas of military affairs, science, politics, fashion, sports, music, environment, etc. This makes it possible for you to determine what pictures will best illustrate various ideas. It is also easier to communicate with a wide variety of people if you keep yourself well informed. To keep up, you should talk to all kinds of people; watch television; go to movies; and read newspapers, books, and magazines. The base library is also a very rich source of information and should be used on a regular basis. To this end we will briefly discuss the library system.

Library Classification Systems. Libraries contain thousands of books and, obviously, there has to be



CALL NUMBER (DEWEY DECIMAL SYSTEM)
AUTHOR'S COMPLETE NAME
DATE OF BIRTH
FULL AND EXACT TITLE
PAGING
DESCRIPTIVE NOTE
IMPRINT: PLACE PUBLISHER, DATE
OTHER ENTRIES UNDER WHICH THIS BOOK MAY BE FOUND

919.6 Schenck, Earl 1890

Come unto these yellow sands, by Earl
Schenck; illustrated by the author.
Indianapolis. New York. The Bobbs-Merrill
Company (1940)

372p. illus 24cm

"First Edition"

1. Polynesia-Description and Travel
I Title

Library of Congress

231-637

Figure 3-2. Information found on catalog card.

some way of keeping up with them and locating them quickly. Therefore, libraries arrange their books according to some system. The most commonly used one is the Dewey Decimal system.

Dewey decimal system. Under this system, 10 broad classes include all books. Each class is assigned numbers as follows:

000—GENERAL WORKS (bibliography, newspapers, periodicals, etc)
100—PHILOSOPHY (ethics, logic, psychology, etc)
200—RELIGION (theology, Bible, etc)
300—SOCIAL SCIENCES (law, education, political science, economics, etc)
400—PHILOLOGY (study of written records, linguistics, etc)
500—PURE SCIENCE (physics, mathematics, astronomy, etc)
600—USEFUL ARTS (electrical engineering, radio principles, wireless communications, etc)
700—FINE ARTS (*photography*, music, sculpture, etc)
800—LITERATURE (of all countries)
900—HISTORY (geography and travel, ancient, modern, biography, etc)

The system further divides each of the 10 broad areas into 10 subdivisions. In turn, each of the subdivisions is divided into 10 parts. Finally, each part is divided into 10 classes and a decimal number is assigned to each. This system gives you a precise number by which you can look up the book.

Card catalog. The card catalog is the key to the use of the library. It allows you to locate all the books in the library quickly and easily. It contains alphabetical index cards by author, subject, and title. The card catalog consists of cabinets with drawers containing cards. A label on the front of each drawer tells you at a glance that the cards are listed in alphabetical order. There are guides in each drawer to help you locate information without having to thumb through a large number of cards.

You can locate books from three types of cards: author, title, and subject cards. Figure 3-1 shows that the same book is filed three ways. You can see that the three cards contain exactly the same information. The difference is in arrangement. The author's name comes first on the author card, the title first on the title card, and the subject first on the subject card. By including the three types of cards, the card catalog makes it possible for you to locate a book if you know only the author, the title, or the subject with which it is concerned. Securing information from a card requires that you understand the basic information on the card as shown in figure 3-2.

Other available sources. In addition to books, the library is a continuing source for newspapers, magazines, maps, atlases, directories, dictionaries, encyclopedias, etc. Remember to ask the library's trained staff to help you solve any research problem you may have.

NOTE: Magazines are a particularly rich source of ideas for photography. The *National Geographic* and *Vogue*, for example, provide a "photo education" with every issue.

Exercise (612):

1. Complete the following statements on the use of the library.
   a. Most libraries use the ________ ________ ________ to arrange their books.
   b. The Dewey Decimal system uses ________ broad classes to organize books.
   c. Under the Dewey Decimal system, photography would be found in the ________ hundreds.
   d. If you know either the ________, ________, or ________, you can look up a book using the card catalog.
   e. ________ are particularly rich sources of photographic ideas.

3-3. Select Equipment and Materials

You must know all the tools of your trade. In this sense you might be compared to a composer of music. Your cameras, lenses, and lights are like musical instruments. Just as a successful composer knows what his instruments can do and employs them properly, so must you choose the proper camera, lights, film, and processing to get the most out of the job you have to do.

613. List the factors which must be considered in selecting equipment and materials for an assignment of any type.

When preparing for an assignment you should consider three factors—the product requested, the shooting conditions, and the time requirements. Let us briefly discuss each one.

Product Desired. Whether the requester wants slides, color, or black-and-white prints, or combinations of these will set limits on your choice of film, processing, printing, and camera equipment. For example, slides require the use of a 35mm camera, reversal color film, and appropriate processing. This film restriction alone may preclude your choice to one camera. The requester may instead want both color and black-and-white prints. Color negative film can give you both products and it is available in a wide variety of formats, so your choice of a camera becomes much greater.

Shooting Conditions. The who, what, where, when, and why of your assignment will be the biggest factors in your equipment and film choice. A few examples will illustrate the problem. An architectural assignment normally calls for a view camera and the necessary cut film. A crash and accident can be best handled with a press camera and roll film or film packs. A football game is easiest to shoot with a 35mm reflex camera and a variety of lenses. Whether the event is indoors or outdoors, daylight or nighttime, or on a beautiful sunny day or in downpouring rain will, for example, call for decisions on film speeds and accessory lighting.

Each job should be analyzed in terms of additional equipment as well. A view camera, for example, requires a sturdy tripod and a cable release. Filters are often required for accurate tonal rendition or color balance. You should always carry a properly working light meter. Remember, there is nothing more embarrassing than to travel for an hour or two to the shooting spot, get set up, and then realize that you have forgotten a piece of equipment that will make the difference between a "half-baked" job and success.

Time Requirements. Considerations of time may require particular equipment solutions. For example, a quick identification picture may be satisfied with Polaroid. A job that requires only a few shots, but has a "short fuse" on delivery may be best handled with a 4 x 5 press camera and cut film.

It must be stressed that you should carefully analyze your work order prior to going out on a job. You should develop a standardized check list that should be followed so that you have the equipment you need with you. Such preparation will save you time in the long run because it will reduce the number of re-shoots and it will prevent your shop from getting a poor reputation.

Exercise (613):

1. List the three factors that should be considered when choosing film and equipment. Briefly explain why each is important.

3-4. Inspect and Test Equipment

The Commander of SAC has come to present an award to the Base Commander. You have all the dignitaries in position for the presentation picture. You click the shutter but the electronic flash does not go off. How do you explain this failure? Checking of equipment prior to going out on assignment is the best way to save such red-faced embarrassment.

614. Explain techniques and procedures used in the inspection and testing of photographic equipment.

Visual Checks. Visual checks of camera and lab equipment give a good indication of their condition and usability. This visual check shouldn't be a quick glance but a thorough examination of condition. For example, suppose you are checking a camera bellows. A casual examination of the item may indicate incorrectly that the bellows is in perfect condition. Instead, extend the bellows to its maximum and, in a darkened room, place a light inside. If you cannot see any light leaks, the bellows is in good condition. Examine all items with the thought in mind that something is wrong and prove to yourself that they are all in satisfactory condition. It is surprising how many pitfalls you can avoid by looking for trouble in advance.

Operational Checks. Operational checks should be performed on each item of equipment. There is a danger of losing a photograph by a mechanical malfunction. This applies to lab equipment as well as the camera and accessories. Any item that must function to contribute to the final product should be considered as a possible trouble spot. For example, without a functioning focal plane shutter a 35mm reflex camera can become a useless object. Therefore, you should check the camera shutter very carefully prior to going out on a mission.

There is a tendency to let seldom-used items, such as tripods and filters, slip by in the initial test. We may use a press camera daily and yet use the filters or tripod less often. Don't let such usage lead you into a sense of false security. Check each item against a check list that you have prepared.

Preventive Maintenance. Preventive maintenance might be defined as those minor maintenance procedures which are performed to prevent excess wear or other damage to equipment. A small amount of oil on a squeaky bearing may prevent such a bearing from becoming damaged. Such preventive maintenance is mainly up to you and your common sense. It may include simple techniques such as tightening a loose screw or greasing a gear. Such maintenance will prevent costly breakdowns. Let us consider three general categories of preventive operator maintenance—adjustments, cleaning, and lubrication.

Adjustments. Adjustments must be made periodically if top quality results are to be expected from your camera and lab equipment. Technical manuals for each piece of equipment contain the procedures for making any required adjustments such as zeroing a light meter needle. When you do make an adjustment, be sure you follow the proper procedures.

Cleaning. All equipment, whether it is constructed from wood, metal, glass, or plastic, should be kept clean. Dust or dried chemicals can raise havoc in any photographic process, from the beginning to the final product. All cleaning should be done with the appropriate cleanser for what is being cleaned.

Lubrication. Periodic lubrication of any functional camera and lab equipment is a necessity. Points where friction is created will wear any time the correct amount or correct viscosity of the lubricant is not maintained. On any equipment, the unit, its location, the method of application, the lubricating period, and the type of lubricant are specified in the applicable technical manual.

NOTE: Remember, the extent of operator maintenance may vary from one laboratory to another. Limitations are due to the availability of maintenance personnel, the time it takes to send out a piece of equipment for repair, and the applicable regulations and technical orders which spell out areas of responsibility.

Exercises (614):

1. What is the purpose of a visual check?

2. Why are operational checks important?

3. What is the advantage of performing preventive maintenance?

4. List and briefly explain three techniques that are applied in preventive maintenance.

5. What limitations may there be on operator maintenance?

3-5. Portrait Photography

A portrait is not just another photograph. It is a carefully composed portrayal of a person often used for publicity purposes or as a method of identification. (Identification and passport photography will be covered in a later section.) Good portraits do not just happen—they result from careful application of many different techniques. Above all, good portraits usually result from many years of experimentation and practice. Making good portraits requires both artistic and photographic ability. Portraiture often involves working with persons of senior rank, children, and members of the opposite sex. Self-confidence and the ability to handle people properly are extremely important.

615. State the requirements for portrait photography.

Portraits are an important part of any base photo lab mission. Portraits are used in personality features, for key-man and chain-of-command displays, and for the very important AFR 36-93 requirements. Let us discuss each one of these.

Personality Features. People are interested in other people. On every base there are thousands of individuals who are contributing to the Air Force mission. Their individual accomplishments can be spotlighted by a picture story. Such a story would be highlighted by semiformal and informal portraits of the individual. The majority of these pictures would be taken at the individual's place of work or when he is taking part in the activity that has made him stand out.

Groups, too, can be considered. Portraits of the winning softball team or a group of volunteers who make monthly visits to a home for the aged are common examples. These portraits are taken on location and emphasize the group's particular accomplishment.

Key-Man Pictures. Each level of command has key personnel who hold leadership functions. To spotlight their responsibilities, their portraits appear on bulletin board displays. Such portraits are usually head and shoulder poses taken in the studio. They should be dignified military portraits.

Chain-of-command pictures follow this same principle. In each headquarters building there is usually a display of photographs showing a chain of command stretching from the President to the base commander, etc. Many of these photographs are supplied by higher authority. The pictures of the local commanders are similar to the AFR 36-93 format that will be discussed next.

AFR 36-93. AFR 36-93, official photographs, requires officers to maintain official photographs in their personnel records. These photographs are important as they become part of the officer's promotion folder. The updating of these pictures is spelled out in the regulation. As photographers we are most concerned with the following specific picture requirements.

> A formal pose of officer showing head and shoulders with the face directly toward the camera and the body turned approximately 45° to the right so that the left shoulder is forward, wearing blue service uniform with coat (but no headgear) and badges and ribbons indicating authorized awards and decorations, is required. 8 x 10 inch glossy black

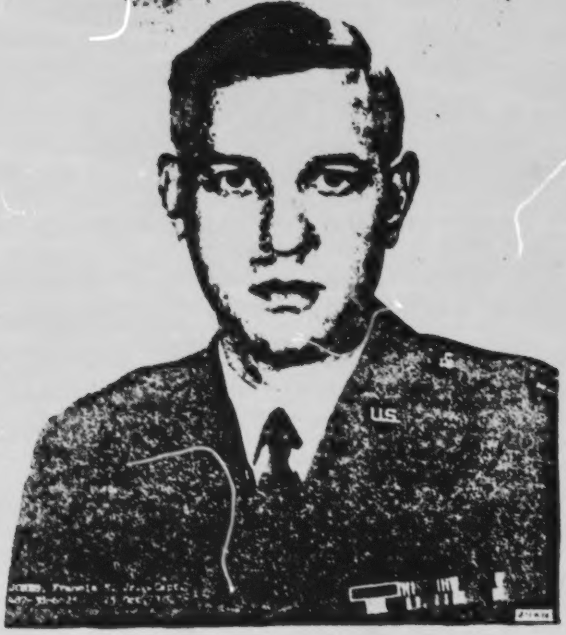


Figure 3-3. Official officer's portrait in accordance with AFR 36-93.

> and white prints only, with 1/4 inch border on top and sides and 3/4 inch border on the bottom. Name tags will not be worn. The officer's name, grade, Social Security Number (SSAN), and date photograph was taken will be inserted in lower left corner of each print, 1 inch from lower edge. Gummed or pressure sensitive labels will not be used to record identification data on photographs.

It is very important that a current form of the regulation be available at all times, as the officer will be relying on your knowledge and judgment to carry it out. It will require quite a bit of tact on your part to point out to an officer when his appearance or dress does not conform to the necessary standards. (Fig. 3-3 shows an example of a 36-93 photograph.)

Exercises (615):

1. What is the key ingredient of the personality portrait?

2. List three basic categories of portraits you may be taking.

3. Why is it important to keep up with AFR 36-93?

4. Why must you often exercise tact when taking 36-93 portraits?

616. Complete statements on portrait technique.

The majority of your portraits will be taken in the controlled environment of your lab's portrait studio. The principles of good portraiture are also applicable to location shooting. To help you along we will discuss equipment, working with the subject, composition, perspective, and lighting. It must be emphasized, because of the number of variables and infinite possibilities, that only through practice and intelligent analysis of your results can you master this very rewarding photographic skill.

NOTE: It would be to your advantage to read about and examine the work of such great portrait artists as Arnold Newman, Yusof Karsh, and Phillippe Halsman.

Equipment. Prior to the portrait sitting it is important to analyze the work order so that you have a clear idea of the requirements. A "36-93" may call for a different approach from that of photographing the president of the Officers' Wives' Club. The finished product that is required will also be an important factor in determining the type of film and the camera you will be using. Thoughtful preparation will save you time and ensure good results.

Generally, you will be using a 4 x 5 or 8 x 10 camera for portraiture. Such large negatives permit retouching and produce high quality enlargements. You will want to use a fine grain film and developer combination to ensure top quality.

It is essential to have your equipment ready for use before the portrait sitting begins. Check lamps, flash units, shutter, film holders, support equipment, and general camera operation. Have one of your associates assume the position you plan to use. While your assistant is in the correct position, establish the general lighting effect desired, the camera position, and the approximate bellows extension for proper focus. Go through the normal setting up operations that are required. After all of the preparatory steps have been completed, turn off the lights and await the arrival of your subject(s).

Putting the Subject at Ease. Many persons freeze in front of the camera. If you know what you are doing and if you can give the subject the impression that you understand your business, it will go far to dispel his nervousness. When posing the subject, verbally direct him into the desired position. A good portrait photographer seldom finds it necessary to touch the subject. However, if you must adjust clothing or do something for the subject that he is unable to do for himself, be polite, explain why the action is necessary, and ask permission to take the action. Remember that most people become very annoyed when they are "pushed about," but they usually cooperate readily if you are polite, gentle, and give adequate reasons for the action that is being taken.

NOTE: Portrait subjects are normally quite concerned with their appearance. It is a good idea to construct dressing rooms with mirrors to provide a place for people to "check themselves out" before the sitting.

Portrait Composition. The simplest form of portraiture is undoubtedly confined to head and shoulder shots. Apart from placing the head, there are few compositional problems. When more of the subject is included, as in a three-quarter shot, the placing of the hands and the pose of the figure becomes of great importance.

Since personal comfort leads to more graceful positions being assumed, it is usually desirable to give the subject some support. For example, in the case of a head-and-shoulders portrait, a stool may be used. A full-length portrait, of course, permits no support.

The background is very important. Most portraits are posed against a very plain background. Many of these backgrounds are in effect portable screens designed for portrait studios. If you keep the background well away from the subject, you will throw it out of focus and create an appearance of space.

Your choice of focus and depth of field will be an important factor in how pleasing your composition will turn out. Normally, you focus on the eyes and use a fairly wide open f/stop to insure rapidly decreasing sharpness. The purpose of the portrait is for the face to stand out from the environment. Occasionally, when doing location shots or where a particular prop related to the subject is an important element in the picture, greater depth of field may be necessary to get your picture message across.

NOTE: When shooting color consider the color of the subject, background, and any props. It is important that there be a harmonious blending of these various colors.

Perspective. The perspective of a portrait will be determined by the position of the camera in relationship to the subject. Whether the camera is near or far, high or low, or at eye level will make a difference in how the subject will appear. Normally, for a head-and-shoulder portrait, the camera is level, with the optical axis of the lens between the height of the subject's lips and tip of his nose. For a three-quarter figure shot, the center of the lens is level with the upper chest. For a full-length figure, lower the camera again until it is level with, or a little below the waist. You should also maintain a good working distance so you do not have any distortion.

NOTE: There are recommended focal lengths for different size films and types of portraits in order to maintain a good image size. For example, consider these for a 4 x 5 camera: 8½" to 10" for a head and shoulders and a 6" for a full length.

Lighting. Lighting along with subject placement is the key element in successful portraiture. Lighting can come from either natural or artificial sources or combinations of the two. Its direction and intensity will determine how the contour of your subject's face will appear.

The single most important principle you should apply to achieve correct lighting is that there should be only ONE DOMINANT LIGHT SOURCE with all other lights subordinate to it. To do otherwise will cause confusing shadows and light directions. To better understand this, let us consider the use of four lights: main, fill-in, hair-light, and background. Using these four lights in the studio will allow you to perform almost all of your portrait assignments.

The main light. Generally, this is a flood lamp or broad light source located higher than the subject's head and at approximately 45 degrees to one side of the camera-subject axis. The light is often diffused with a screen to reduce facial textures and eliminate harsh shadows. The positioning of the main light is the key to your lighting and therefore must be considered with great care. Normally, you will use it to establish either broad or short lighting. (See fig. 3-4.)

In broad lighting the main light fully illuminates the side of the face turned TOWARD the camera. This type of lighting is mainly used to help "widen" thin faces.

Using the far more common short lighting, the main light illuminates fully the side of the face turned away from the camera. This lighting is used for the average

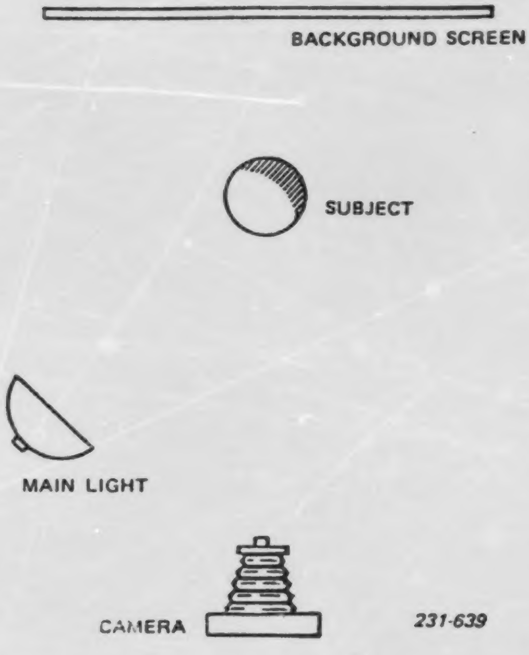


Figure 3-4. Positioning the main light.

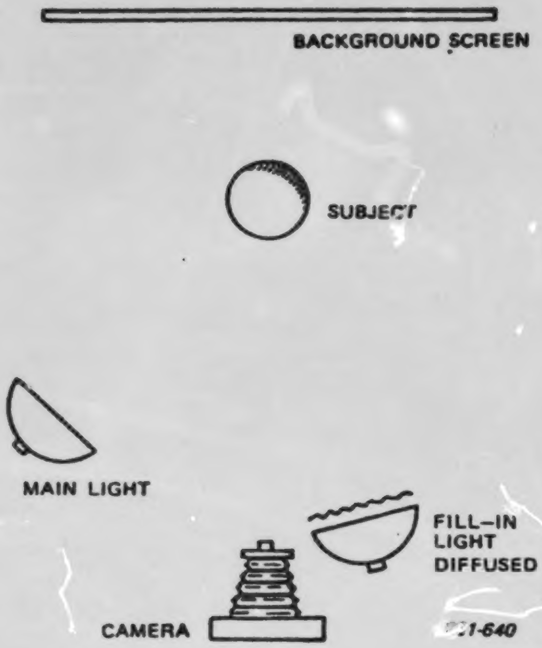


Figure 3-5. Add the fill-in light.

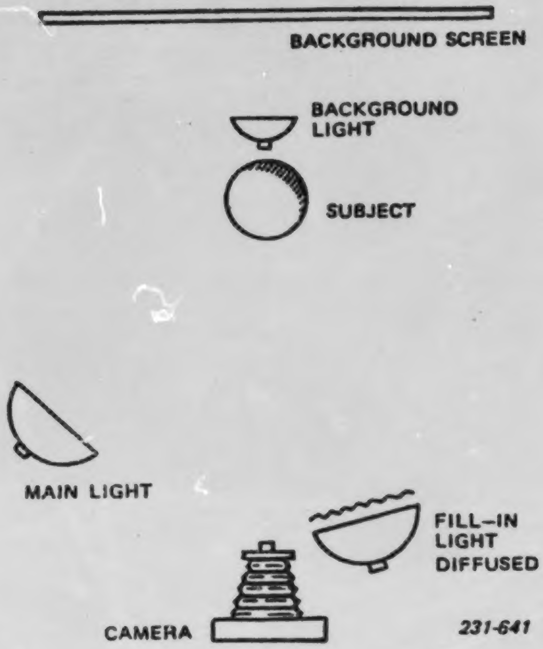


Figure 3-6. Add the background light.

oval face and it tends to emphasize facial contours more than broad lighting. Its effect can also be used to narrow plump or round faces.

One method of placing the main light, regardless of the type of lighting, is to watch the resulting catchlight (reflection of the light) in the eyes. As seen from the camera-lens position, these catchlights should be located at approximately the 1 o'clock or 11 o'clock position in the eyes depending on the result desired.

NOTE: To position electronic flash units you will have to rely on a modeling light. The use of a modeling light takes experience as it is often much weaker than the resulting flash. This is why it is better for the beginner to learn portraiture using photoflood lamps.

The fill-in light. The fill light is diffused, used close to the camera at lens height, and placed on the side of the lens opposite that of the main light. Its purpose is to soften the shadows cast by the main light. (See fig. 3-5.)

Almost inevitably the fill light will add a lower pair of catchlights to the eyes. These secondary catchlights should be etched from the negative or spotted from the print to create a more pleasing effect.

The background light. The background light is a small lamp on a short stand placed about midway between the subject and the background. This light provides good tonal separation between the subject and the background. (See fig. 3-6.)

The hair light. This is usually a small lighting unit attached to a boom so it can be established above and behind the subject. Normally, the light is positioned

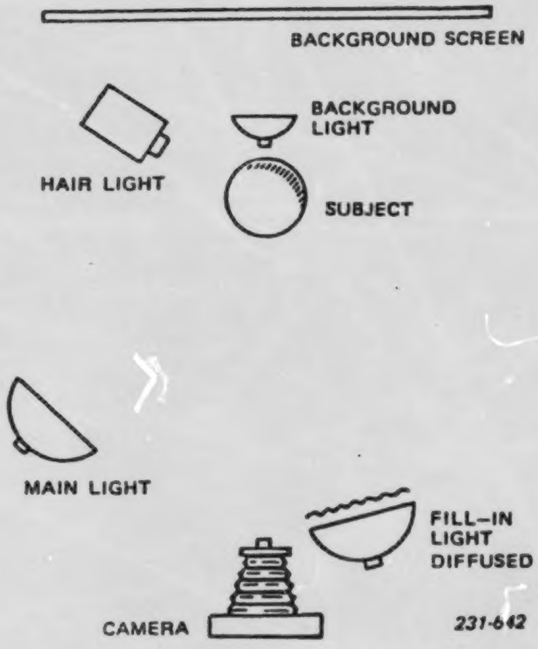
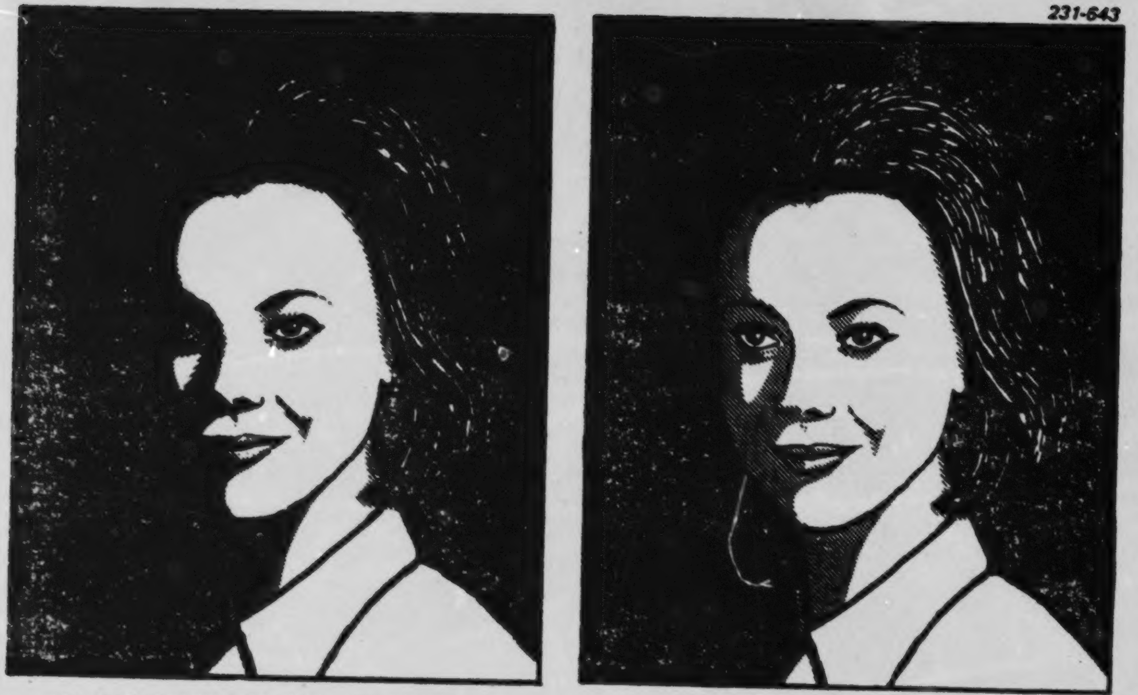
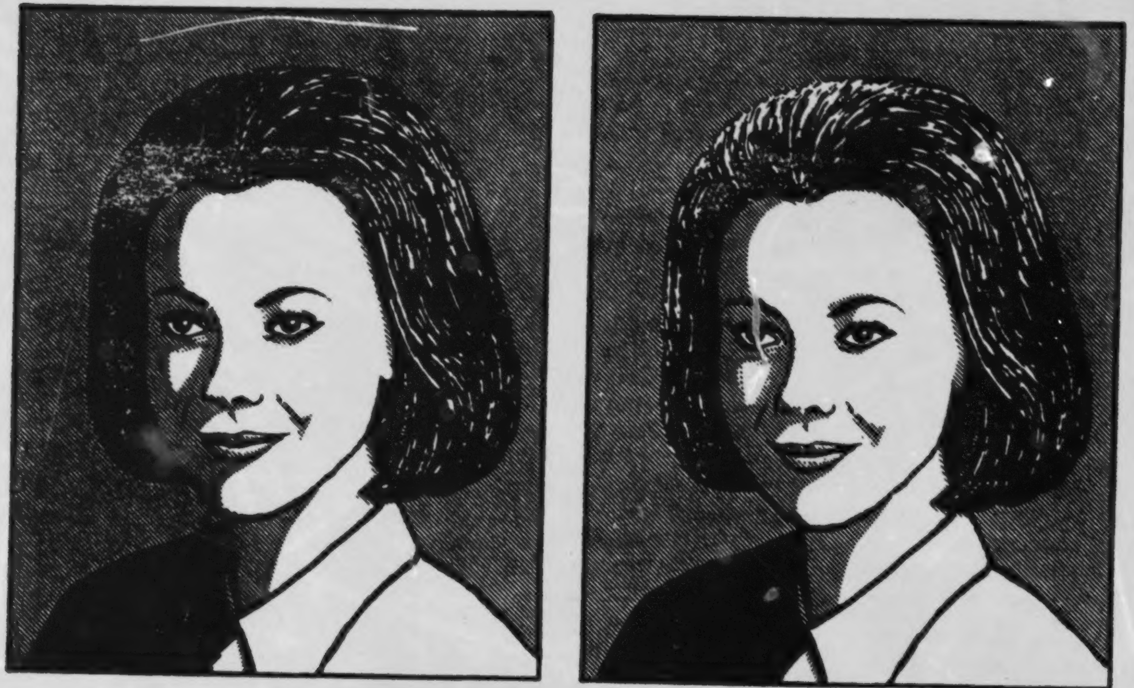


Figure 3-7. Add the hair light.



A. BROAD LIGHTING (MAIN LIGHT ONLY)

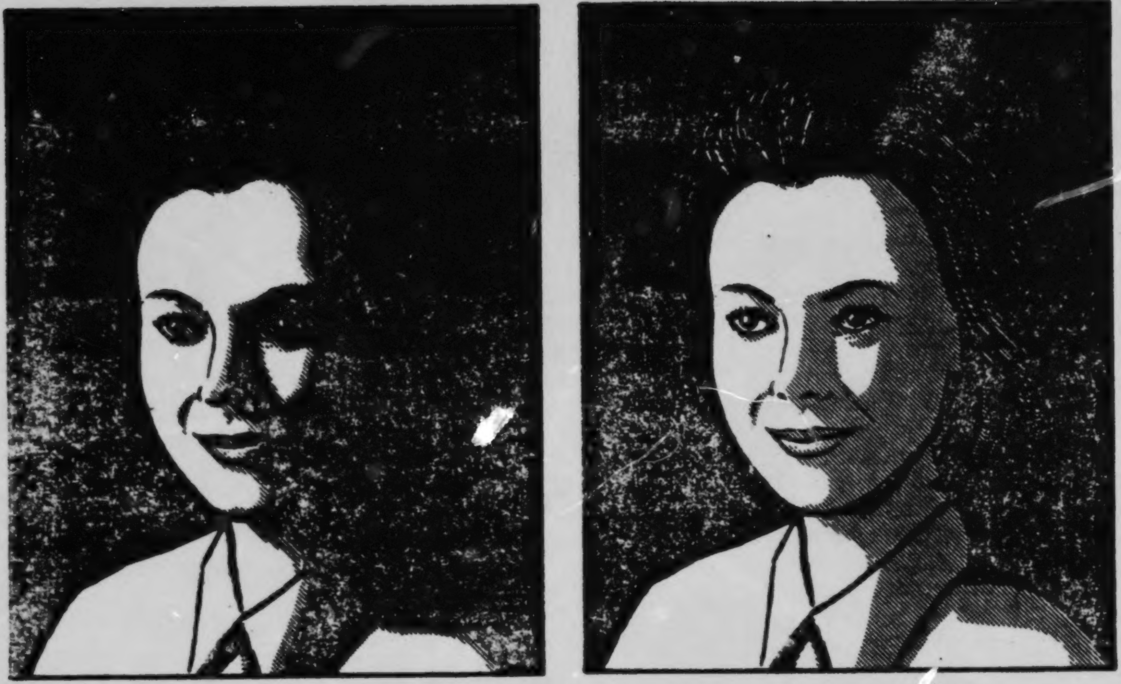
B....ADD THE FILL LIGHT



C....ADD THE BACKGROUND LIGHT

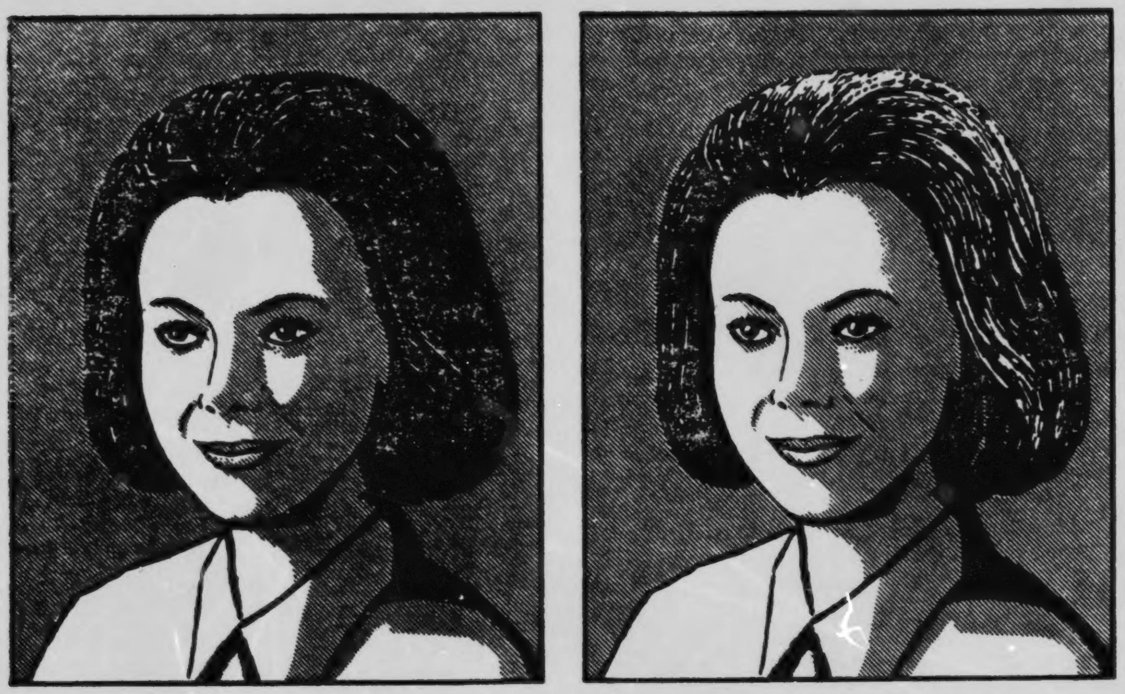
D....ADD THE HAIR LIGHT

Figure 3-8 (a,b,c,d). Broad lighting.



A. SHORT LIGHTING (MAIN LIGHT ONLY)

B....ADD THE FILL LIGHT



C....ADD THE BACKGROUND LIGHT

D....ADD THE HAIR LIGHT

Figure 3-9(a,b,c,d). Short lighting.

directly overhead, either to the right or the left of the subject's hair at head level, or above and to one side. The key is don't let the light spill over onto the face, thereby creating unwanted hightlights. (See fig. 3-7.)

NOTE: To establish the lighting the way you want it, it is best to position each light separately with the other lights off. Some photographers start with the background light, then move to the main, fill-in, and hair lights. (To better understand the difference between broad and short lighting using four lights, compare fig. 3-8 with fig. 3-9.)

Lighting ratio. Lighting ratio refers to the relative intensities at the subject position of the main light plus the fill-in light, as compared to the fill-in alone. This ratio creates the contrast of the portrait. Normally a ratio of 3 to 1 will result in pleasing contrast. Higher ratios are more dramatic but are likely to be unacceptable for official record portraits. Here are a couple of ways to establish a 3 to 1 ratio:

- Establish both the main and fill-in light at equal distance from the subject, but cut the strength of the fill-in by one half. This can be done through power settings or by the using of a diffusing screen over the fill light.
- With two lights having the same strength, move the main light one f/stop closer to the subject. For example, if the fill light is 11 feet away from the subject, the main light should be 8 feet away.
- Take an exposure meter reading (reading may be incident, reflected reading off a gray card or the use of a flash-meter) at the subject of the main plus fill-in, and then the fill-in alone. In this way you can calculate your ratio.

Portrait lighting is exciting and requires quite a bit of practice to be expert. Take the time to practice this skill so you will be ready for your first portrait mission.

Exercise (616):

1. Complete the following statements on portraiture.
   a. By using a large format camera you will have portrait negatives that can be __________ and readily __________.
   b. The subject will not __________ in front of the camera if you establish rapport.
   c. When taking a portrait, you normally focus on the subject's __________.
   d. Normally when taking a portrait, you will want __________ depth of field.
   e. For a three-quarter shot, the center of the lens is level with the subject's __________ __________.
   f. When using a 4 x 5 camera, you would use a ______ inch lens for a full-length portrait.
   g. There should be only __________ dominant light source when taking a portrait.
   h. To position electronic flash units, you must rely on the __________ lights.
   i. In broad lighting, the main light fully illuminates the side of the face turned ________ the camera.
   j. In short lighting, the main light fully illuminates the side of the face turned ________ from the camera.
   k. A lighting ratio of __________ will give you pleasing results.
   l. The main light plus the fill light, as compared to the fill, establishes the ________ ________.
   m. The __________ light is used to provide separation between the subject and the background.
   n. The __________ light is usually attached to a boom.
   o. To establish a 3 to 1 lighting when the main light is 5.6 feet from the subject, a fill of equal strength should be placed __________ away.

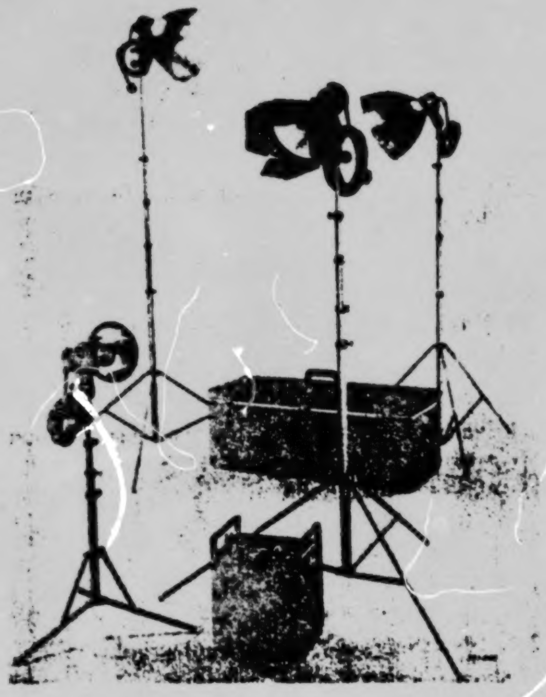


Figure 3-10. "Ascor" Series 360-1 lighting group.

617. Identify techniques used in photographing different portrait subjects.

Corrective Techniques. Human nature being what it is, people appreciate a portrait that brings out the best features and tones down the worst. By the proper use of equipment and lighting techniques, you can achieve this desired outcome to a great degree. The following is a suggested list of techniques you can use to make each person look his best.

Problem	*Possible Solution*
Broad Face	Raise the camera position. Use short lighting. Turn the face to the three-quarter position.
Narrow Face	Lower main light. Use broad lighting.
Wrinkled Face	Lower the main light. Use diffused lighting. Use a three-quarter pose.
Facial Defects	Keep the defects in shadows.
Baldness	Lower the camera position. Use no hair light. Use a screen to shade the light striking the head.
Prominent Forehead	Tilt chin upward. Lower camera position.
Long Nose	Tilt chin upward. Face is directed toward the lens. Lower the main light. Lower the camera position.
Angular Nose	Turn the face more toward the lens.
Prominent Ears	Hide far ear behind the head. Keep near ear in shadow. Consider a profile view.
Deep-set Eyes	Lower main light. Use lower lighting ratio.
Protruding Eyes	Have subject look slightly downward.
Glasses	Tilt glasses downward by elevating bows slightly. Adjust fill light laterally. Have subject raise or lower chin slightly.
Narrow Chin	Tilt chin upward.
Double Chin	Raise main light. Tilt chin upward. Use high camera position.
Heavy-set Figure	Use short lighting. Use low-key lighting. Vignette shoulders and body. Blend body with background tone.

Exercise (617):

1. Identify the technique listed in column B used to correct the defect listed in column A.

Column A	*Column B*
1. Narrow face ______	a. Short lighting
2. Angular nose _____	b. Turn face toward the lens
3. Double chin ______	c. Lower camera position
4. Baldness________	d. Broad lighting
5. Heavy-set figure ___	e. Use higher camera position

3-6. Electronic Studio Lights

Studio type lighting systems are of two basic types—continuous and electronic flash. Continuous lighting sources provide uninterrupted picture taking light. Such light sources as photofloods and quartzhalogen lighting units come within this category. Since the light is continuous it is easy to direct and to measure. For the beginning portrait photographer this is a great advantage. The lights, however, are rather "hot" for the subject.

More studios are now using the quick, powerful but intermittent light of electronic flash. Such a light source provides very powerful illumination that matches daylight in terms of color temperature. Its brief flash is easier on the sitter. Through the use of continuous modeling lights the photographer can judge to some degree the effect of his set up. The lighting ratio can be determined by calculations based on the various power settings available with each unit. In this section we will describe the "Ascor" series 360-1 location lighting group which can be used in the studio or on location, as an example of electronic flash units.

618. Complete statements on the use of electronic lights.

The "Ascor" series 360-1 location lighting group, shown in figure 3-10, is an electronic flash lighting kit designed for use either in the studio or on location assignments. The kit consists of four lights, a four wing barn door, four adjustable light stands, and a portable power supply. All components except the power supply fit inside a lightweight carrying case. The power supply is housed in its own protective cover which also acts as a carrying case. Both the carrying case and power pack are equipped with convenience handles.

The four lights in the kit are coordinated to meet a variety of studio and location lighting requirements. Two 12-inch light assemblies are provided for use as main and fill lights. A 5-inch background light and a 5-inch hairlight with barn door are also included. Each of these lights can be operated independently or in any possible combination. Each light reflector fixture contains both a plug-in type flashtube and a modeling lamp. All flashtubes and modeling lamps are of the same type and are completely interchangeable.

A barn door assembly on the hair light controls spill light and permits complete directional control of the light. Four separate barn door wings mounted on a 360° rotating ring assure exact placement of the light beam from the hair light.

Each light in the kit is supported by an adjustable light stand. The stands are equipped with folding legs and telescopic risers. Stands for the main, fill, and hair lights extend from 29 inches minimum to 132 inches maximum. The backlight stand extends from 16 inches to 46 inches. All of the stands compress for storage and transport in the carrying case.

The separate power supply is rated at 400 watt-seconds output. It features 3 to 4 seconds full power recycle times (time between flashes), continuous operation, and internal voltage regulation. A ready light indicates when recycling time is complete and the unit is ready to deliver 100 percent light output. Internal circuit breakers protect the power unit from accidental overloads. Required power input is 115 volts AC, 60-Hertz. The 400 watt-second output is divided into two power banks, one providing maximum power for each lamp and the other power to the lights.

The lamps are placed to provide optimum lighting of the subject being photographed. The vertical height of each lamp is controlled by adjusting the telescopic riser. Tip and tilt of the lamp is changed by adjusting the lamphouse fixture in the mounting bracket on the top of the riser. Light spill is controlled by adjusting the angle of the barn door wings and rotating the position of the barn doors on the hair light. Once adjusted, all lamp fixtures, stands, risers, and barn doors are held in place by securing lock screws with thumb or hand pressure.

Each of the four lamp power outlets on the power pack is equipped with a fail to flash warning system. A misfire results in an audible warning and an indicator lights up next to the specific outlet on the power supply unit. This indicator permits ready isolation of any misfired lights or malfunctioning circuits.

NOTE: Remember your electrical safety when working with lighting set ups. Do not work with frayed cords or bare wires. Make sure that there is no overload on any circuit. Follow all manufacture directions in setting up and operating the particular unit. A well-done job means that it was done safely.

Exercises (618):

1. What does a barn door control?

2. What happens when a flash fails to fire when using the Ascor lights?

3. What is the purpose of a telescopic riser?

4. Name two safety problems you may encounter when setting up lights.

3-7. Identification-Passport Photography

Nearly all Government agencies and military installations use photographs on passes, identification cards, badges, and passports; and in personnel files and records as one of the means of positive identification of personnel. For each particular assignment, the requirements of size, pose, etc, may differ. Therefore, before you make any exposures, consult the appropriate regulations to determine the exact requirements that the photographs must meet.

619. State the requirements and some of the photographic techniques used in identification and passport photography.

You must never forget that the purpose of the identification photograph is just that—a photograph from which the person can be identified. Its purpose is not to "glamorize" the subject or make the individual look "pretty"; it is to portray any and all features, both good and bad, which serve to identify that particular individual from all others.

Photography is one of the most positive and economical methods of identification. For this reason pictures have long been used for identification purposes. In recent years, there have been two noticeable trends in identification photography: (1) the emergence of new and varied applications, and (2) a sharp increase in the use of color photos. Let us therefore take up the requirements of passport and identification photography.

Passport Photography. There are a number of official photographs which include naturalization, identification, citizenship, and passport photographs. Air Force Manual 211-2, *Passports*, provides information and procedures concerning the submission of Department of State Passport Application, Form DSP-11. Two duplicate signed photographs, taken within six months of application date, not smaller than 2 1/2 x 2 1/2 inches nor larger than 3 x 3 inches, are to be presented with the application. (*USAF Foreign Clearance Guide*, provides additional guidelines.)

Photographs which depict the applicant as a relaxed and smiling person are welcome; however, they shall be clear, frontview, and full face in either color or black and white. They are to be printed on thin, unglazed paper base with a light, plain background. This permits the signature along the left-hand side of photograph to match the application signature, yet not mar any features of the photograph.

Snapshots, magazine, or full-length photographs are not acceptable. Neither are film base, acetate, or vending machine prints since they must withstand a mounting temperature of 200°F.

AFM 211-2 stipulates that any passport photograph will include only one individual. This includes infants if at all possible. The reason for this policy is that on numerous occasions a mother has had to return to CONUS on an emergency basis and is forced to leave her children in someone else's care in the host country. The mother, requiring the passport to leave and reenter the host country, leaves the children with no official papers or status, thereby causing international political complications.

Identification Pictures. Identification pictures are made for use on all types of military ID cards and classified area badges. Identification photography is often done by the Security Police as identification forms are normally filled out and registered in the Security Police, Pass and ID section. The size of the identification picture cannot exceed 1 x 1 1/4 inches in a vertical format. It must be a full front shot of the face and cannot be retouched. The picture will also include a title board containing information set down by pertinent directives.

This type of identification photography is often done with a Polaroid camera designed for identification work. Such a camera permits quick results with a number of different lighting setups. More importantly, a non-professional photographer can be trained to operate it and make the necessary adjustments to obtain satisfactory results.

Lighting. The lighting arrangement used for any identification or passport type picture must be even, well-balanced, "flat" lighting. This type of lighting will not hide any identifying facial marks, such as scars, moles, etc, which could be used for definite identification of the individual. To obtain flat lighting, both the main and fill light are placed at a 45-degree angle to the subject, giving you a 1:1 lighting ratio.

Exercises (619):

1. What is the purpose of identification photography?

2. Why must passport photography be printed on the right kind of material?

3. Why must individual passport pictures be made of each member of an Air Force family?

4. What type of lighting is used in identification photography?

3-8. Photojournalism

What is photojournalism? Photojournalism is the means of telling a story with photographs normally supported by captions or a written story. Unlike news photography, which aims at one or two telling pictures to support a current event, photojournalism relies on a group of pictures that reveal a subject in depth. Normally, there are three common types of photojournalistic forms: the picture sequence, the picture story, and the picture essay. The picture sequence is usually a step-by-step display of an event or task such as the steps in fixing a radar scope. A picture story is usually a multi-picture report on an event, person, or other subject of interest. Rather than a step-by-step approach, the pictures highlight different aspects of the subject. For example, a picture story on basic training might highlight marching, obstacle course, firing range, and barracks life as experienced by a basic airman. Finally, the picture essay allows the photographer freedom to express himself on a broad theme. Different pictures illustrating the concept of "Peace Is Our Profession" would comprise a picture essay.

The key to successful photojournalism is, of course, the man behind the camera. You must be highly proficient, and the camera must become part of you. By your becoming proficient, innovative, and dependable, you will be able to tackle photojournalism stories which will bring you a great sense of pride and respect.

620. Explain shooting and captioning techniques that are used in photojournalism.

Shooting Principles. Photographic quality is essential to the photo essay. Innovative composition to tell the story and technical excellence to carry it through reproduction is a must. The pictures must be eye-catching to attract and hold reader interest. In addition, the engraving necessary for magazine and newspaper reproduction requires prints or slides which are very sharp and of good tone (or color) and contrast.

When shooting a photo story, the photographer has more time to think, plan, and execute each shot. He is also able to shoot many more shots than when he is on an everyday work order. Many pictures do not represent a waste, but better insure successful coverage by giving the editor a variety to choose from.

By shooting a sequence of long, medium, and closeup shots of each phase of the story, the photojournalist provides flexibility in picture selection. Long shots (use of a wide-angle lens) give a good feeling for the overall scene. While such pictures may be rarely used, they help in understanding the event and the importance of the other pictures. They help the editor lay out the other pictures. Medium shots which show the subject and a bit of the surrounding environment will often provide the majority of the pictures. However, it is the dramatic closeups which give a sense of intimacy with the subject and stimulate reader interest.

A good sense of timing is important to shooting success. The majority of picture stories cover uncontrolled action. It is essential that you capture the dramatic and fleeting moments that illuminate your story. To do this, you and your equipment must be ready. You should thoroughly know your subject. By being ready and knowing your subject you will be able to anticipate what is likely to happen. For example, you may be doing a story on missile launchings. By having the necessary equipment ready and knowing how missiles are launched, you will be able to anticipate when the missile will be launched. Remember, a missile launch, a home run, or a Presidential handshake will not be repeated for your benefit.

Captioning. When shooting your story you should keep a notebook of the time, dates, names, locations, and facts associated with the event. This will help you, the writer, and the editor to better understand your pictures. In this regard you may be called upon to write picture captions.

A caption is usually made up of four basic parts: (1) explanation of the action; (2) identification of persons or objects in the photograph; (3) additional details or background information, and (4) the credit line. The who, what, when, where, and why of the substance of the picture is covered.

Action. The first sentence is the most important one in the caption. It must link the photograph to its caption by describing the action in the photo. One of the peculiarities of the first sentence is its present tense verb form. The reason for this is that photographs, like paintings and sculpture, capture one moment of time and keep it in the present.

Another reason for using the present tense in the first sentence is that it gives the reader a sense of immediacy, as though he were actually witnessing the event shown. Thus a caption which reads, "Sgt James T. Berger swims through the swirling flood waters of the Merrimack River to rescue 6-year-old Wendy Koza . . ." has more dramatic impact than one which reads "Sgt James T. Berger swam through . . . ."

One problem which arises from the use of the present tense is what to do with the when (time) element. To put the time element in the first sentence would result in a sentence such as, "General Jones flys a B-1 bomber yesterday . . . ." Needless to say, this poor grammar jars the reader and should be avoided. To alleviate this problem, the time element in captions is usually left out of the first sentence.

Identification. This includes an identification of all persons and objects vital to the story telling function of the photograph. The question of who should be identified poses the biggest problem, and we provide only general guidelines. The basic idea is to identify everyone who is identifiable and pertinent to the story. By identifiable, we mean a person who is not blurred, or obscured, or too far away for recognition. By pertinent, we mean a person who is involved in the central action of the picture. The idea is to identify anyone in a photograph who attracts the reader's attention.

The identification is placed as high as possible in the caption. It may be identified along with the action. With group identification it may be better to list the names after the first couple of sentences. Identification can be done in several ways. The best way is by action. If Joe Smith is passing a football to Sam Jones, it should be obvious from the photo which one is passing and who is receiving. Another is by contrast. If there are two airmen with Miss Universe, it is not necessary to identify Miss Universe as being left, right, or center in the photo. Slightly more complex is identification by elimination. In a presentation shot, the action of the general pinning a medal on a sergeant identifies both these individuals. The recipient's wife is identified by contrast and the squadron commander is identified by elimination. Finally, there is the old fashioned method of identifying people from left to right.

Background. Background information gives additional facts and explanation to explain the significance of the picture. The amount of background information will depend on the clarity of the photograph and the knowledge of the readership. For example, identifying a plane as the C5-A may be all that is necessary if the picture is carried in a military magazine. The same caption would be grossly inadequate for a civilian audience.

Credit Line. The credit line gives the source of the photograph. This may be the photographer's name or the agency which provided the photograph.

Exercises (620):

1. Why are pictures with good composition essential in photojournalism?

2. What three basic types of shots are used to cover a picture story? What is the purpose of each?

3. Why is timing important in photojournalism?

4. What are the four basic parts of a caption?

5. List four different methods to identify people in a group shot.

621. Distinguish between different types of story-telling sequences used in photojournalism.

Continuity. Composition is of great importance in photojournalism. Each picture has to have impact and communicate an idea or feeling that relates to the point of the story. This story relationship that each picture must have is an idea you must keep in mind. A dramatic picture just won't be published if it doesn't support the story idea. So when you are composing a shot for a picture story, you have to keep in mind the relationship of this particular picture to those that were shot before and those you plan to shoot. This relationship between pictures is called continuity.

Six continuity types that are frequently used to hold picture stories together are as follows:

- Simple chronology
- Narrative chronology
- Repeated identity
- How-to-do-it
- Parallel or contrast
- Development of a theme

Simple chronology. A simple chronology format is used when there is a group of pictures on the same subject that does not have to be arranged in any particular order. In other words, the pictures may have no starting point and no conclusion but can be arranged, like a family album, in the order in which they were taken. The pictures are held together by their common subject matter. For example, a picture story on the history of a particular base could present the pictures simply in terms of the oldest first.

Narrative Chronology. Unlike the simple chronology, the narrative chronology is presented with a definite time sequence in mind. It has a definite beginning, suspense, and dramatic conclusion. Each picture is closely related to the one before and the one that follows and cannot be taken out of sequence. An air-sea rescue would be an example of this type of picture sequence. Pictures of the crew waiting in the ready room, the scramble, the rescue at sea by landing an amphibious craft in choppy seas, and then the return with ambulances waiting at the field require a definite sequence.

Repeated identity. This type of continuity is one of the simplest to develop and the one most commonly used in publications today. In its basic form, it involves the repeated use of the same person (repeated identity) in every scene in the picture story. For example, if the photographer wants to develop a picture story of basic training in the Air Force, the easiest way of doing it is to select a typical recruit and follow him through a day of training from morning to night. The same recruit is in every picture, but each picture shows a different action.

How-to-do-it continuity. The how-to-do-it continuity employs a time sequence of pictures showing step-by-step procedures. It is used to show how to perform different tasks from loading a bomb to making a splint. This format is the basis of how-to-do-it articles that are so popular in hobby magazines.

Parallel or contrast continuity. Parallel continuity involves comparing the progress of two subjects who are in the same or similar circumstances—for example, the progress of a foreign and an American student undergoing the same pilot training. Contrast is also used in the "do and don't," "right and wrong," or "before and after" type of story. The "do and don't" approach is commonly employed in a story on safety. The "right and wrong" technique can be used effectively in a feature on military courtesy. The "before and after" approach is often used in picture stories dealing with progress.

Development of a theme. Most picture stories have a theme; that is, they present an argument or idea through pictures that are logically related to each other. In fact, you may be assigned to illustrate just that, an idea. Assignments like "Christmas Time," "Force in Readiness," "Norton AFB 1976," can give you the greatest freedom to express yourself. Such assignments call for the greatest planning so the idea of the story is not lost.

Exercises (621):

1. If you wanted to show a day in the life of your base's top aircraft mechanic, which type of continuity are you likely to use?

2. What is the difference between simple and narrative chronology?

3. What type of continuity should be used in a safety article regarding the use of fire extinguishers?

622. Given a hypothetical journalistic assignment, prepare a brief shooting outline.

Shooting Script. Thoughtful preparation is the key to successful photojournalism. The development of a shooting script or outline can bring all the planning together. The script should contain a comprehensive listing of every picture idea the photographer has developed, including possible camera angles, points of focus, lighting, accessories to be used, and similar helpful information. Such a script defines the scope of the shooting and provides a "wall" for bouncing off fresh approaches to the problems involved. It is not a rigid lock step to be "marched" to until the job is completed.

A good script is divided into two parts. The first is concerned with the general idea of the picture story. All pertinent information as to names, places, times, and contacts are located in this part. The "what" or scope of the subject is used to organize the theme of the story. The second part lists the picture ideas and information pertinent to each shot. The two main qualities the photographer should demand from his shooting script are accurate facts and completeness.

The following is a typical script:

Part 1:

a. WHO: Name of Subject
Smith, John X., TSgt, FR 123 45 6789
Instructor 3ABR23132 Course
Department of Audiovisual Training
Lowry AFB, Colorado.

b. WHAT: Scope of Subject (Theme)
School instructor and class during training situation in the 1st block of instruction.

c. WHEN: Best Possible Time to Shoot
Subject. The class is engaged in practical work each day of the week. Shoot during the practical assignment which is from 1300 through 1700 hours daily.

d. WHERE: Shooting Location (building, street, or working areas)
Bldg 383 and the south side and the grounds directly adjacent to Bldg 380A, Lowry AFB, Colorado.

e. WHY: Reason or Purpose for Shooting Subject
To inform the American public of the training received by Air Force photographers in the 3ABR23132 Still Photographic Specialist Course.

f HOW: Possible Contacts at Shooting Location
Master Sergeant Jones, telephone extension 4142.

Part 2:

a. SHOT 1: LONG SHOT
School instructor in field with students. Shoot overall shot of instructor with entire class.
WHY: Establishes the general training situation.

b. SHOT 2: MEDIUM SHOT
Instructor working with two students, adjusting the Speed Graphic or pointing out to the students the proper method of viewing a scene. Use a shallow depth of field, and about waist-level camera position.
WHY: To identify an instructor and a couple of students attending the photo school.

c. SHOT 3: MEDIUM SHOT
Instructor pointing out to a student a special point of interest about the scene being photographed. Shoot over student's shoulder, using a shallow depth of field.
WHY: To show instructor and student discussing the job plan on which the student is working.

d. SHOT 4: MEDIUM SHOT
Instructor checking a 4 x 5-inch film holder. Shoot just past the student's shoulder at the instructor—about waist level.
WHY: To show the reader the concern of the instructor relative to the equipment and the student with whom he is working.

d. SHOT 5: CLOSE-UP
View of the instructor looking through the ground glass of the camera, with student behind instructor.
WHY: To show the instructor helping the student to photograph the subject.

f. SHOT 6: CLOSE-UP
Instructor explaining the function of the front standard on the Speed Graphic. Shoot from a waist-level position.
WHY: To illustrate to the reader the intricate instrument with which the student completes his assignment.

g. SHOT 7: MEDIUM SHOT
Instructor discussing problem with the student. Try to have the student showing something to the instructor.
WHY: To show the reader the interest of the instructor in the student.

h. SHOT 8: MEDIUM OR CLOSE-UP
At a light table an instructor looks at a negative. The student and instructor discuss the quality of the negative. Shoot from the opposite side of the light table, from a high

angle, to show negative on the light table. Use available light. The light table will light up the faces of the student and instructor.
WHY: To show the evaluation of the student's work by the instructor.

NOTE: This is of course just a sample script. The script could be much longer or shorter than this, depending on the nature of the assignment. Even the format is not important. The key is to plan what you are going to do. By writing down your ideas you are less likely to forget what you are going to do.

Exercise (622):

1. Develop a brief three-shot part II of a shooting script to be used for a fire prevention week sequence about the hazards of smoking in bed.

3-9. Industrial Photography

Industrial photography is a broad term covering the many uses of a camera to portray and assist man in showing his role as a producer of goods and services. Industrial photography records the constantly changing story of a nation at work, earning its living, harnessing an unimaginably huge output to create wealth, useful products, and a better way of life. The Air Force ia a major "service corporation" that has as much output as the largest corporations in America.

623. State some requirements and techniques of industrial photography.

Industrial photography is more of a broad subject category than a "separate" shooting technique. Portraiture, architectural, close-up, and photojournalistic techniques are all applicable to illustrate the accomplishments of any company. In fact, Air Force photographers are basically industrial photographers.

Normally, industrial photographs are used to obtain a visual record that can be referred to at a later date to show progress or change. Through the use of the photograph there can be wide distribution to all levels of command as well as to the Air Force community at large. Projects such as the developmment and success of the BMEWS radar system in the Arctic, the preparation and lift off of an ICBM missile, or the construction of a new hospital can be understood through complete photographic coverage of all stages of planning and execution.

What Makes a Good Industrial Photograph? A good industrial photograph has all the elements of any fine photograph—good lighting, composition, and technical execution that bring about the very clear communication of an idea. In addition, the photograph must be functional. Industrial photographs are used for very practical purposes. The majority are used to show objects, processes, or the work of individuals. They must provide information that can be used by commanders, engineers, and technicians.

Research and Planning. Industrial photography calls upon a photographer to have a clear understanding of the requirements of the requester. This demands that the photographer have an understanding of the particular industrial process to be shown and how to translate it into photographic terms. For example, your base communication squadron wants pictures of repair work being done on a mobile command truck. To the requester this means a couple of 8 x 10 glossies of the command radios and a technician working on them. To you it means what camera, film, lighting, and shooting angles should be used. The burden rests on you to get the job done. You have to understand what techniques will best show the radio, command truck, and the technician. To put it simply, you have to learn about the requester's job while he doesn't have to learn about yours. You have to learn about heavy duty equipment, lathes, circuit boards, telephone poles, radio repair, and welding to be an effective industrial photographer. This is necessary so you can translate the industrial activity into photographic terms.

Equipment. An industrial photographer, since he is shooting inside and out, in black and white and color, and under a variety of conditions, must be able to use all types of equipment. An architectural shot of a new building calls for a 4 x 5 view camera. An inside shot of repairing planes in a hangar will require extensive use of supplementary lighting. Filters are needed to balance different types of lighting to color film. On any industrial assignment, good planning will insure your having the right equipment for the job.

Safety and Good Housekeeping. Each picture should show proper safety and housekeeping practices to be acceptable. The requester will not accept a picture that will show his section in a bad light. Each worker in the picture must be following proper procedures. Photographically you might prefer that the technician not wear his goggles, but if his job requires a pair (for example, a lathe operator) he must be wearing them when you photograph him at work. The work area should be neat and clean and not violate fire and safety practices. You must, therefore, take care when you are setting up your picture to make sure that the background as well as the foreground elements do not violate these principles.

Shooting Techniques. Remember, the purpose of an industrial shot is to convey information. When photographing the new base hospital, it is not so much its artistic beauty but its potential for service that you want to show. Normally, most requesters want a clear, sharp picture that shows their activity. This does not mean you cannot be "creative." The key is to shoot the assignment in several different ways so that the requester has a choice between the routine that he has gotten in the past and your "fresh" outlook toward the job.

Here are a few ideas you might apply to your next industrial job.

- Extreme close-ups make any tool or machine look big and impressive. It is also the only way to show detail in small objects.
- High or low camera angles can provide fresh viewpoints of common subjects.
- Silhouette lighting can be effective to dramatize shapes and forms.
- Through multiple exposures you can combine the detail obtainable only during daylight with the drama created by a sunset.
- Use open flash to light large interiors such as a hangar.
- Use a slow shutter speed to emphasize the speed of a particular process such as the whirl of a lathe.
- Use people to add interest and show techniques and size relationships.
- Use a telephoto lens to get you close, make the subject look bigger, or compress space.
- Use a wide angle lens to shoot in cramped quarters or to give an overall view.
- Look for repeated patterns that show output of an operation.

Exercises (623):

1. What is the purpose of most industrial photographs?

2. Why must a photographer understand the requester's activity?

3. Why must an industrial photographer be particularly aware of the background, shop area, and operator procedures?

4. What is the advantage of using close-up shots of machinery?

5. What is the advantage of using silhouette lighting?

3-10. Sports and Action Photography

Every base newspaper has a sports section to display top photographs. Both players and spectators enjoy action-packed shots that sum up the excitement of the various events. Whether it is shooting a squadron softball match, an interservice track meet, or the Olympic Games, there are plenty of opportunities for the sports knowledgeable photographer.

When we think of action photography in the Air Force, combat action comes immediately to mind. Combat action may be air-to-air or air-to-ground. It may be some form of ground support action. But no matter what form the action takes, it demands that you cover it from all angles or positions, in all kinds of weather, and under all light conditions. A combat photographer takes the risks of war to inform his commanders, comrades, and the American people what the Air Force is doing. It is the most challenging and demanding of any assignment a photographer can get. Yet it is the ultimate purpose of every Air Force photographer's training.

624. State principles, techniques, and requirements of sports photography.

Sports Assignments. The first step in a sports assignment is preparation. You must research the sport. Usually, the sports assignment goes to the cameraman with an interest and knowledge of the event, and you may meet these requirements. But regardless of your knowledge of the sport, it pays off to refresh your knowledge by researching the players. Players are specialists in their field. Some break fast and move with deceptive speed. Others excel under the basket or at bat. Know the players and their characteristics. With this knowledge you can get the jump on the action when it is at its peak. For example, if a ballplayer known for his base stealing prowess is on first base, you should be ready for the action of a steal. You should also know the stadium where the event will take place so you know the possible shooting positions.

Equipment. The speed of action demands choosing equipment that is designed for stop-action photography. Whenever available, use a 35mm reflex camera, variety of lenses, high shutter speed, strobe lighting, fast film, and a motor drive. A motor drive attachment on your camera enables you to shoot photo sequences almost as if you were using a "movie" camera. An exposure that is a little too late or a little too early isn't good enough. The punch in sports photography lies in recording the instant when the player's intensity of expression and effort are at their peak.

A telephoto lens is indispensable for bringing the action in close. The camera position and angle, as related to the action center, often prevent getting the shot with a normal lens. A telephoto lens lets you get into the action and catch the intensity of the player. Many sports activities take place under lights, or under conditions that require supplemental lighting. Under these conditions the use of strobe lighting has become almost universal. The strobe is also ideal for stopping fast action at its peak.

NOTE: Remember to realize that a strobe has only one-fourth of its normal effect when used in a large arena or outside. In addition, make sure that your lighting does not interfere with the performance of the players.

Photographer's attitude. Shooting a sports assignment requires mental and physical agility to stay ahead of the play. You must anticipate the action. Be prepared. Move fast. Be alert for human interest shots off the playing areas as well, such as the expression on the face of the coach; or the excitement or despair of the crowd.

Let's cover an auto race. Let us put our training together by "shooting" an auto race. First we should know the type of race, the time, the race course, and the kind of product we need to produce. In this way we can design a proper shooting plan. Suppose we are going to cover a daylight sports car race at Ontario Speedway, located in southern California. We are going to produce color slides.

First, a study is made of the race course so that possible shooting positions can be ascertained. The key spots in any auto race are usually the curves, the pits, and the start and finish lines. At a big race course it is impossible to cover all places. Normally you need to cover the pits prior to the race to shoot the preparations that are being made, the start and finish lines at the beginning and end of the race, and one or two key curves during the race. Once a shooting plan is worked out, then you can inventory your equipment. For example, two Nikons with motor drives; 20mm, 28mm, 85mm, 105mm, 200mm, and 500mm lenses; skylight filter to cover all the lenses; tripod; meter; and fifty rolls of thirty-six exposure Kodachrome 25 film. We should now be ready.

When race day comes you need to arrive early, hustle all day, and stay until the end of the main event. In this way you will better guarantee award winning coverage that will justify all the hard work.

NOTE: Most sporting events are sponsored by private organizations. To get in close or even to take pictures may require a press pass or specific permission of the sponsor. Make sure that if needed you have such clearance for the event you are covering.

Exercises (624):

1. In order for a photographer to cover a sports event he should have a good knowledge of what?

2. What type of camera is likely to be used for sports?

3. Why should you know the playing field where the sport is going to be held?

4. What should you remember when using a strobe during a sports event?

625. Complete statements related to the techniques of combat photography.

Combat Photography. Planning for this type of assignment is similar to sports planning in that you will be photographing uncontrolled action. In fact, it is far more uncontrolled for it goes forth, without rules, over a much broader "playing field" than any sports event. You must be in top physical condition as you will be required to fly combat missions as well as accompany ground troops in the field. You must be mentally alert and emotionally stable to capture the fast paced, death dealing events.

The equipment must be small and fast handling. Two 35mm cameras (one rangefinder for its quietness and low light focusing capability and one reflex for telephoto work), a couple of lenses (examples, 28mm, 50mm, 80-210 zoom), filters, meter, film, a notebook, a couple of tools, and a cleaning kit are what you basically need. It is similar to what you might use in photojournalism, but with these thoughts in mind:

- You cannot use flash in a combat zone because it will attract the enemy. Therefore high-speed films are a must.
- You do not have time for a normal size tripod. Unless you have a photo clamp or table-top type of tripod, you must normally rely on natural objects or equipment to support your camera for any time exposures you might need.
- You must keep equipment to the bare essentials because you will have to carry your military gear as well. On a flying mission you may be further limited because of space and weight requirements of the plane.
- You must be able to carry all the film you will need as it is difficult to be resupplied during field operations.
- You will often need to take care of your equipment yourself. You must protect it and the film from mud, water, sand, dirt, etc. Waterproof pouches come in handy for this task.

The best place to practice the art of the combat photographer is during practice maneuvers and operations. During such assignments you can get a better idea of what equipment and techniques work best for you. It is truly inspiring to see the work of famous combat photographers such as Eugene Smith, David Douglas Duncan, and the Air Force's MSgt

John Stoudt to realize what can be done under such trying conditions.

Here are a few shooting techniques you might consider:

- Use the wide-angle lens to get an overall view of the combat zone. This gives a good idea of the scope of the operation and the general positions of the forces.
- Use the telephoto lens to get you close to the action.
- Use the principles of framing and leading lines, etc, to draw attention to the key point of interest.
- Anticipate the high point of the action. For example, catching the bombs being released during a tactical air strike.
- Action at night can create dramatic silhouettes. Also, a nighttime exposure of the battle can give truly interesting results.
- Portraits of the soldiers and airmen involved are the most telling of all pictures. Such views show the tension, grief, pride, and the gut determination of our forces.

Exercise (625):

1. Complete the following statements on combat photography.
   a. Combat photography covers action which is far more _________ than sports.

   b. You cannot use _________ in a combat zone because it is likely to attract the enemy.

   c. Normally you must carry all the _________ you will need because of limited resupply.

   d. Wide angle lenses are used to give an _______ view of the action.

   e. _________ usually are the most telling of all combat pictures.

3-11. Close-Up Photography

Close-up photography (sometimes called macrophotography) is not a type of subject, but a technique to make large images on film by getting close to the subject. There is no rigid rule as to what constitutes a close-up, but methods that achieve at least a 1:1 or larger image certainly qualify. These image sizes are achieved through the use of special lenses, lens attachments, bellows, extension tubes, and even microscopes. (When microscopes are used it is called photomicrography and often requires specialized techniques.) Close-up photography has wide application in industrial and unsatisfactory report photography.

626. Explain the techniques and procedures used in close-up photography.

There are a number of techniques and types of equipment that can make close-up photography a valuable tool for you. Let us consider equipment, exposure, and lighting.

Equipment. Close-up photography can be accomplished with a view camera that has a double bellows extension. A double bellows extension increases the distance from the lens to the film to twice the focal length of the lens, thereby producing a 1:1 image. A triple bellows extension is also possible for even greater image sizes. The view camera, therefore, would be ideal for the majority of your close-up work because of its large negative size and many adjustments.

The only type of small camera that is really suitable for close-up work is the reflex type. Through the use of special equipment, cameras like the Nikon F, can be put to work. Consider the following attachments:

1. A variety of macro lenses are available that focus very close to the subject and can give 1:1 reproduction.
2. Close-up attachments, which are optical elements that screw into the front of the lens like a filter, give closer than normal focusing capability and thereby permit a larger image.
3. Extension tubes are rigid tubes that mount between the camera body and the lens. Different tubes can be combined to create different effective focal lengths. The longer the focal length the larger the image size.
4. Bellows attachments are available that, like the extension tube, fit between the camera body and the lens. Unlike the extension tube, a bellows permits continous adjustments through its accordian range, and therefore is more versatile.
5. Telephoto lenses can also be selected whereby the design ("macro" feature) or the use of attachments permits you to focus within a couple of feet or less of the subject. This permits a greater shooting distance than shorter focal length lenses while maintaining a large enough image size. This can be of great advantage in nature photography.
6. There are a variety of microscope attachments which permit the use of the camera body and microscope in combination.
7. The normal lens on some cameras can also be reversed and used for close-up work.

NOTE: Close-up photography requires excellent quality lenses. Any type of distortion or defect will be quite apparent with such large image sizes and close focusing.

Focusing. Sharp focusing is absolutely essential. This is why a reflex camera or a camera with ground glass focusing is a must. A rangefinder camera suffers from parallax at close focusing distances. Another aspect is depth of field. Due to the short lens-to-subject distance, and often long effective focal lengths, depth of field is very limited for any given aperture. Therefore, no focusing error is permitted.

Film. Choice of film is important. The fine-grain, high-contrast films that can record maximum detail are probably the best choice, but their slow speed can cause problems. Faster films may not have the contrast or resolving power, but they permit a wider choice of apertures.

Tripod. The camera must be rigidly supported as any vibration will result in a soft image.

NOTE: The subject must also be still. If the subject cannot be held still, such as with a flower or a bird, a higher shutter speed must be used with a consequently larger aperture.

Exposures. Exposure in close-up photography requires test and experience unless your camera is equipped with a behind-the-lens light meter. Reflected readings are difficult to make because the area being photographed is so small. A gray card, however, can be used as a substitute for the subject. Incident light readings often prove easier to take.

However, the basic problem is that the effective focal length usually has been changed through the use of accessories so that the calibrated apertures of the lens are not effective. For example by doubling the focal length of a lens through the use of a bellows, the indicated f/stop becomes one-fourth as effective. This means that if the aperture is set at f/8, its actual effect is as if it were set at f/16.

You can work out the proper exposure increase that is necessary if you know the scale of reproduction. Take the scale, add 1 to it, and then square the result. The resulting equation is $EF = (M+1)^2$. For example, for a 4 times magnification (4:1), the factor would be $(4+1)^2 = 25$. Exposure would therefore have to be increased 25 times over the exposure reading.

NOTE: A big advantage of those cameras that have a behind the lens metering systems is that such an exposure calculation as above is unnecessary. The meter will measure the decreasing amount of light as the bellows is extended or attachments are added.

Lighting. Lighting is essential to good photography and critical in close-up work. The problem is that very little light is being reflected by a subject which is small. Daylight is normally not bright enough, but you can increase its effect through surrounding the subject with reflectors that can increase the overall lighting level on the subject. The majority of close-up work is therefore done with artificial light like photofloods and strobes. Such lights become more useful with the attachment of a barn door or snout to direct the light. The best type of light of all is a ring light (circular electronic flash that fits around the camera lens) which produces very even illumination.

Once you have determined a method to get enough light on the subject for a satisfactory exposure, you should carefully consider lighting direction and ratio. Front lighting with a low lighting ratio is the safest kind and is essential where maximum detail is necessary. For more dramatic shots, side lighting (great for showing textures), cross-lighting, or even backlighting (for example—photographing a spider web) can give you interesting results.

NOTE: Special lighting may be necessary for glassware or other highly reflective subjects. Try bounce lighting, use of a diffuser, or light tent. (A light tent is a tent made of translucent material with a hole in it. Lights surround the tent to cast even illumination on the subject. The camera lens is stuck through the hole to photograph the subject.)

Composition. Composition is as important in close-up photography as in any other type. The large image size is helpful in achieving simplicity. You should consider carefully its image placement. The background should be plain and simple. Different colored posterboards are best for this. Filters can be used to achieve the proper tone or color that is required.

Exercises (625):

1. A double bellows extension will produce what size image?

2. What is the difference between an extension tube and a bellows?

3. Why is there limited depth of field when doing close-up work?

4. Why must you use a tripod when doing close-up work?

5. How much exposure increase is necessary if you are making an 8X enlargement?

6. Why is a ring light an effective lighting tool?

3-12. Accident and Crash Photography

Good photographic coverage of accidents or aircraft crashes is of great value to investigating personnel. When an accident or crash is properly photographed, its cause can often be detected from the photographic record. You must always bear in mind that accidents do not just happen—they are caused. Therefore, it is essential to determine the reason for the accident in order to prevent its reoccurrence.

627. Explain the techniques used for adequate coverage of accident assignments.

The objective of crash and accident photography is to provide good quality photographs to help investigating personnel determine the cause of the accident or crash. For example, in the case of vehicle accidents, the photographs may supply vital information by showing skid marks, point of impact, road conditions, and environment that may indicate the cause of the accident. Some of the things accident photographs can indicate are:

- Carelessness in the operation of a vehicle.
- Loss of control due to speed or a defective mechanism.
- Inadequate control due to physical disability of the operator, perhaps because of illness, intoxication, or drugs.

These same photographs may also be used as evidence in a military court of law.

Photographs of aircraft accidents become an integral part of the investigation. Such photographs serve a dual purpose. First, they help the investigators to graphically reconstruct the events of the crash; second, they provide a means of identification of parts of the aircraft. The distribution of parts in relation to the crash site and the initial point of impact can help indicate what happened during the crash.

Often these photographs are shot in color to show the extent of heat or chemical damage. The use of color also allows the investigating team to determine other factors not easily recognizable in black-and-white photographs. For example, suppose that an internal explosion during flight caused an aricraft to crash. An analysis of the black-and-white photographs reveals that the explosion was caused by the malfunction of a small moving part in the engine. If color film were used, additional facts may be brought to light. For instance, excessive friction on the moving parts leaves a color pattern. A photograph of this part in color would tell the investigators the degree of wear and the temperature caused by the friction.

Emotional Stability. Crash and accident photography requires an emotionally stable photographer. It may be necessary for him to observe other persons suffering from severe wounds, fractures, burns, mutilation, or shock. Additionally, some of the injuries may be sufficiently severe to cause death. Conditions as mentioned, plus the confusion and excitement that normally accompany a severe accident, may cause nausea or even fainting. It is important that the photographer be able to go about his work objectively just as he would if he were covering any other subject. He must not add to the problem already existing. In addition, he must be able to think about the photographic problems involved. He must be calm under the very serious conditions which he may encounter.

Seeking Assistance. If possible, try to find out before you leave exactly to whom you should report when you arrive at the scene. If absolutely necessary, obtain either advice or assistance from the man in charge of the situation. This could be a person representing any of the following career areas: safety, fire protection, security police, investigations, medical, aircrew protection, or the senior officer at the scene. Whatever you do, do not interfere with personnel performing essential duties related to the emergency.

Release of Information. Under no conditions do you have the right to release any information—either verbal or photographic—to activities outside the normal Air Force channels. You must learn that what you photograph is the property of the Air Force. Release information only to the proper authorities, or their representatives, who are charged by the Air Force with a need-to-know.

Mission Planning. Almost every base photo lab has someone available to take crash and accident photographs on a 24-hour, 7-days-a-week basis. This person is known as the "Alert Photographer." Also, almost every photo lab has a particular camera to be used specifically for crash and accident photography and it is usually referred to as an "Alert Camera." If a call is received, all that is necessary is for a photographer to pick up this equipment and report to the scene.

The alert camera kit should be prepared beforehand and should contain film holders or film packs and adapters, flash lamps, and such other material as may be needed to insure complete coverage of the mission. It is important that the camera case be carefully checked for necessary supplies and equipment for proper operation.

Lighting. A major problem related to crash and accident photography is the danger of igniting inflammable vapors or fumes with your photographic lighting equipment. Flash bulbs and to a more limited degree electronic flash are both potential fire hazards. Before photographing any crash or accident, be sure there is no danger of starting a fire. If possible, check with the top officials in charge of the firefighting or rescue operation before making your photographs. It may be necessary to use available light (the light from vehicle headlights, etc.) or special safety lighting equipment to avoid endangering the lives of personnel present at the crash or accident scene.

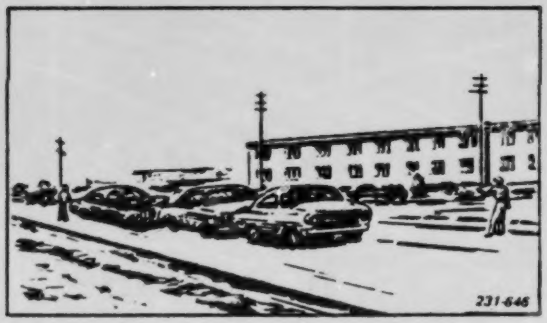


Figure 3-11. General view of vehicle accident showing road condition.

What to Photograph. The photographic coverage needed when a crash or an accident occurs may vary depending on the desires of the investigators. The minimum coverage should include at least the following general coverage: (1) general views of the areas involved, (2) close-up photographs to show important details, (3) photographs of specific parts that might have been the cause of the accident, (4) marks left on the ground that might provide support information, and (5) views that show damage to property—either Air Force or privately owned—resulting from the accident. (See figs. 3-11 through 3-16 for typical accident coverage.)

It is better for the photographic coverage of an accident or a crash to be too complete than not to be complete enough. Extra photographs can always be discarded if they are not wanted; but once the wreckage has been cleared away, it may be impossible to get the desired photographic coverage.

NOTE: The best way to learn the necessary skills of covering an accident or crash is to go out on a few missions with an experienced photographer.

Mission Data Recording. It has been stated earlier that the methods of recording mission data would vary from mission to mission and no specific rules can be applied. Some photo labs specify the minimum data to be recorded when photographing a crash or accident. This data is used to identify negatives and prints, to support various reports, or as evidence in court should a lawsuit result.

If you are assigned to a photo lab where there are no specific rules on mission data recording, the following recommendations can be used as a guide. You should record any information that might be needed. Minimum mission data should include:

1. Type and class of film used.
2. Date, time, and location of accident.
3. Classification.
4. Vehicle, aircraft number.
5. Make, model, and year of vehicle.
6. Tag number and state (civilian).
7. Type of lighting used.
8. Weather conditions.
9. Name of individuals involved.
10. Persons with whom you dealt.

Safety. Observe the general, mechanical, electrical, and ground-safety precautions that apply to the type of equipment you are using and to the area in which you are working. Some of the major precautions to be observed when taking crash and accident photographs are as follows:

1. Stay out of the way of emergency vehicles and do not become a casualty through carelessness.

2. Don't touch anything. You have no authority to change any condition. Photograph objects as they are.

3. Exercise necessary precautions when working in or around flammable substances or conditions.

4. Stay alert and be ready for any unforeseen emergency that may develop while you are taking photographs.

5. Be sure that you are aware of the policies relative to photographing items of equipment that are classified.

6. Do not blind the drivers of approaching cars by flashing flash lamps in their direction.

Exercises (627):

1. What is the purpose of photographing an accident or crash?

2. What is the advantage of color coverage of an accident?

3. Why must an alert photographer be emotionally stable during an accident?

4. To whom should an alert photographer release crash information?

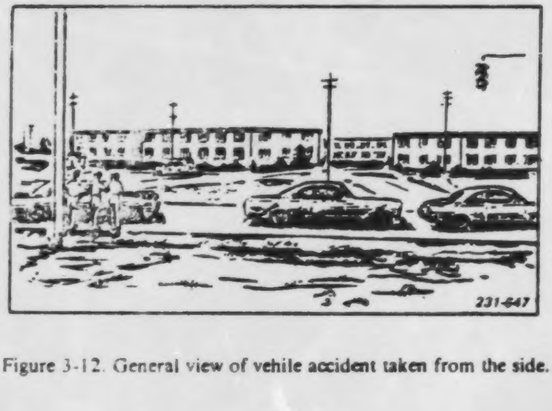


Figure 3-12. General view of vehile accident taken from the side.

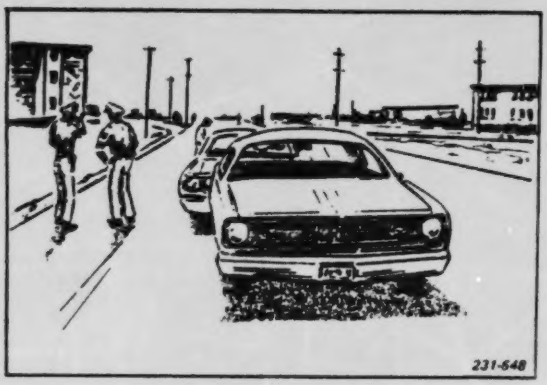


Figure 3-13. General view of vehicle accident taken from the front.

5. What problem is there in using flash during an accident?

6. List five areas of general coverage that should be taken at an accident.

7. What type of mission data is recorded in regard to a civilian automobile involved in an accident?

3-13. Unsatisfactory Materials Report Photography

Technical Order 00-35D-54, *USAF Materiel Deficiency Reporting System Management,* prescribes the procedure for reporting material deficiency data on Air Force equipment and materiel. This TO also prescribes the use of DD Form 1686, Report of Deficiencies Found in Material, for reporting routine deficiencies on systems and material not covered by AFM 66-1, *Maintenance Management.* Emergency unsatisfactory material reports are prepared on material, maintenance, and quality deficiencies which are identified as nuclear, critical, or explosive safety hazards. EUMRs are also submitted on deficiencies which have contributed to, or caused, accidents, incidents, or mission failure as described in TO 00-35D-54. Emergency UMRs are transmitted by telephone, multiple-address teletype, and by radio as necessary, based on the criticality of the deficiency.

Quality UMRs are prepared on material deficiency attributable to nonconformance with applicable specifications, drawings, standard, or other technical requirements. Quality UMRs are also reported on DD Form 1686.

Photographs may be required as exhibits attached to regular unsatisfactory material reports (UMRs) or emergency unsatisfactory material reports (EUMRs) to illustrate an unsatisfactory condition. Either the equipment itself or suitable photographs are required to assist in complete investigation of the cause of the condition.

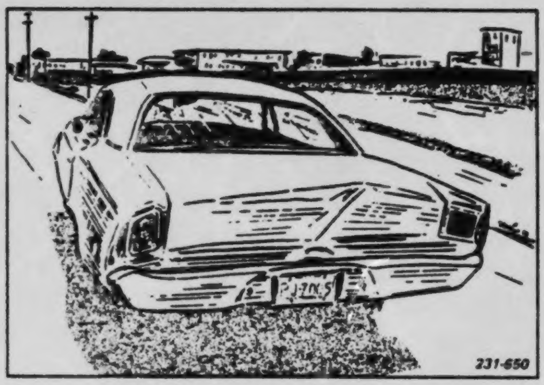


Figure 3-15. Rear view, showing damage to second vehicle.

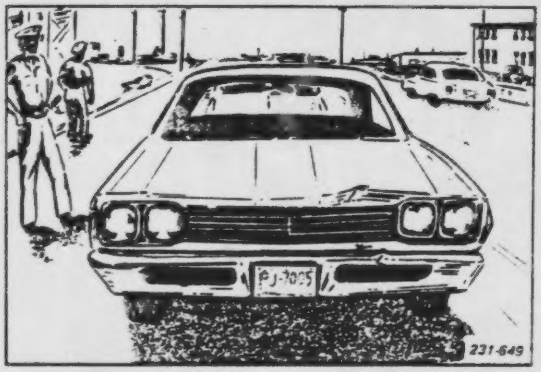


Figure 3-14. Front view, showing damage to second vehicle.

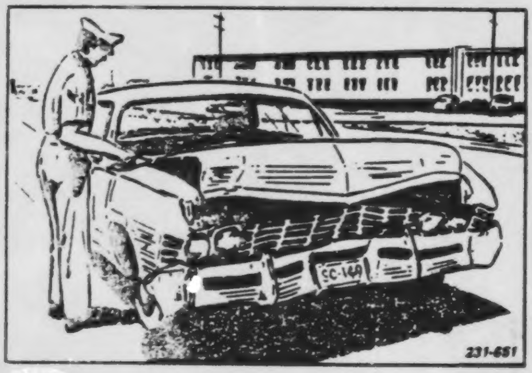


Figure 3-16. Front view, showing damage to the third vehicle.

Figure 3-17. Deficiency report photograph showing main equipment.

628. Explain photographic procedures and techniques used in unsatisfactory materials report photography.

General Planning. To accomplish good UMR photography, you will need the proper equipment and materials. When planning your equipment list, get as much information as possible concerning the UMR project. Find out from the requesting agency whether or not the equipment to be photographed can be brought to the laboratory. This is especially important when small objects are to be photographed, since it allows you a greater choice of equipment, background material, and lighting.

If the item is located outdoors, select the appropriate equipment and supplies. You should ask yourself the following questions regardless of where the job is to be accomplished:

1. How much film is needed? What format? Is slow or fast film required? (You will want to use the finest grain film that you can under the circumstances.)
2. Which type of lighting should be used—available or artificial? Which will give the best results? (You will want as even lighting as possible.)
3. Is it necessary that I take along a tripod? (A tripod is usually essential to insure steadiness.)
4. Is the subject bright or dark? Is it highly reflective? Is texture important? These factors will affect the choice or the direction of your lighting.

Camera Choice. Always use a camera having the largest possible format that you can. This will ensure the best possible enlargements. The 4 x 5 view camera is probably best suited for the majority of UMR work. This is particularly true because adjustments for perspective may be required. Where a view camera is not possible, then a press camera would be the next choice. 35mm cameras are rarely suitable for this type of work because of the small negative that is produced.

NOTE: A copy camera is often suitable where the object is small and therefore can be brought to the lab and mounted on the copyboard. For example, a copy camera is ideal to shoot circuit boards.

Lenses. You should have a variety of lenses available so that you can get the necessary image size for the shooting distance. You should also think about the necessity for both overall and close-up shots.

Preparation of the Defective Equipment. You may need extensive assistance from technicians familiar with the malfunctioning or deficient equipment. Because of the time required for preparation of the defective item for UMR photographs, you should be ready to perform your mission.

It is often advisable to include a piece of chalk and a black grease pencil with your equipment. The chalk is useful in making cracks stand out on a black surface; likewise, a black grease pencil may be helpful in making a crack stand out on a light surface. Common putty or talcum powder can be used to tone down the gloss on highly polished surfaces. If the photograph is to be taken outside the laboratory, try to foresee problems that may occur. A little foresight may eliminate the need for returning to the lab for a small, relatively insignificant item of equipment.

Lighting. Whenever possible, avoid using single-lamp lighting. It tends to give high-contrast

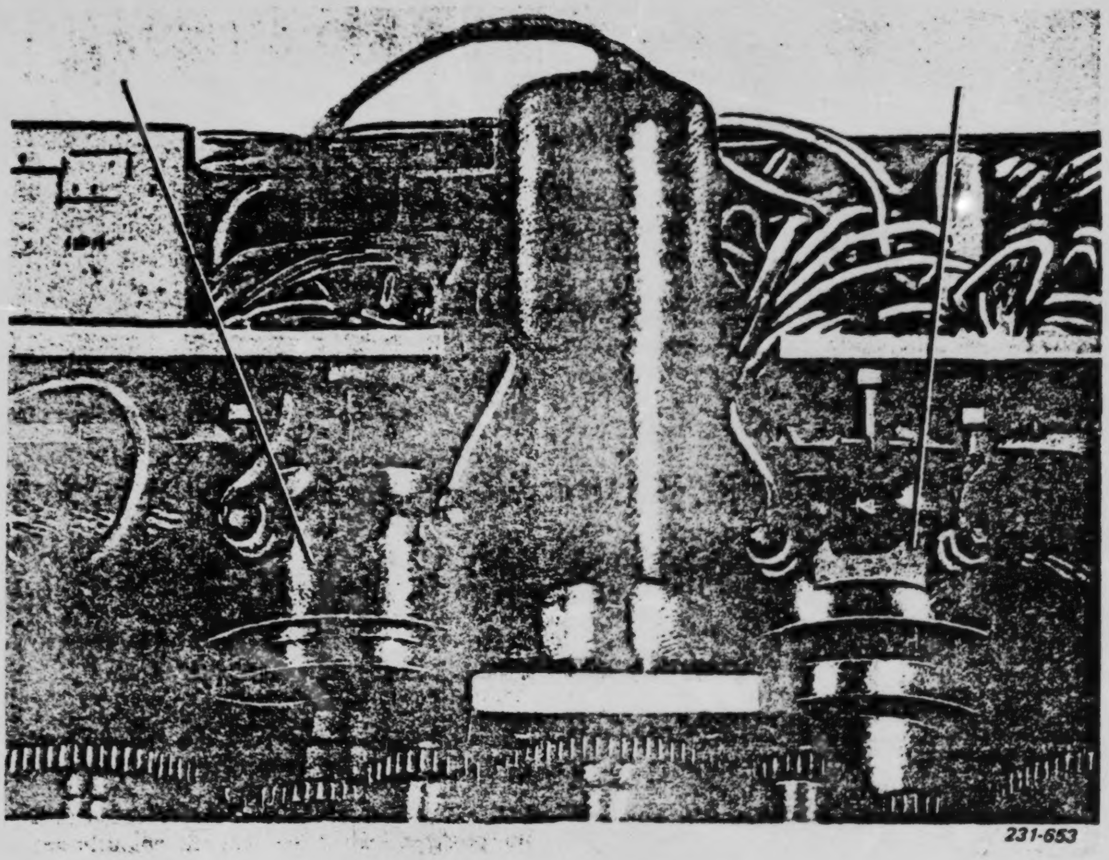


Figure 3-18. Deficiency report photograph showing relationship of main equipment.

photographs that lack adequate detail in the shadows. Normally, you get the best lighting by using two or more floods. You will find that lighting the subject is the key to top results. The lighting must be even so that there is full detail. This may provide quite a challenge in location shooting where the defective part may be in quite a "dingy" spot.

Adequate Coverage. To insure adequate photographic coverage of the defective equipment, work closely with the technicians who normally use the equipment. Make several photographs. First, take a photograph from sufficient distance to indicate what the item is. Then move in toward the defect, showing enough of the surrounding parts of the subject so that those viewing the photograph can tell immediately where the defective part is located with respect to the total equipment. Finally, take at least one close-up of the actual defect, showing the problem area in detail. Change camera angles as necessary to portray the defective component and the specific defect clearly. It is better to take too many shots than not provide enough coverage. (See figs. 3-17 through 3-19 for typical UMR coverage.)

Preparation of the Submission Photographs. An improperly prepared photograph is of little value to the person who must investigate the unsatisfactory report. The following paragraph, quoted from TO 00-35D-54, is noteworthy.

> Each photograph will be marked on the face with identifying and orienting lines, such as aircraft, missile, or space vehicle station number and location so the exact location and nature of the reported condition is shown clearly. When possible, these markings will be placed on the affected part, or adjacent structure, prior to photographing.

Remember, the main reason for forwarding photographs is to avoid shipping the actual equipment. Since the equipment is not available to the investigators, the photographs must be just as good as having the actual equipment. Clarity of detail is essential; coverage must be complete.

Photograph size considerations. There are no specifications as to the exact size for the UMR photograph. A good rule to follow is to keep the size as small as possible, yet show the necessary detail and information.

Since the transmission of the photographs is through the mail, the preferred size is 8 by 10 inches or less; but if it is necessary to submit larger photographs, they should be protected against damage. Sheets of cardboard or mailing tubes are generally sufficient protection.

Print and negative quantity considerations. Although TO 00-35D-54 does not specify the maximum number of prints to be submitted, it does provide guidelines in the following quotation:

> Five prints of each photograph or one duplicate negative will be forwarded to the appropriate AFCL (Air Force Logistics Command) activity.

Exercises (628):

1. What is the advantage of bringing the defective material to the laboratory?

2. What speed of film should you use?

3. What type of camera is ideal for photographing a circuit board?

4. How might you use chalk when you are shooting an UMR?

5. What type of lighting is generally needed in UMR photography?

6. What TO should you consult to guide you in your UMR work?

3-14. Airborne Techniques

There are two broad categories of aerial photography. The first is aerial photogrammetry—the technique of making photographs from which maps may be plotted. The same techniques and sophisticated camera gear are also used in reconnaissance work. The second is largely pictorial and involves taking pictures from the air of buildings, landmarks, installations, bases, missile sites, factories, and aircraft in flight. This second type of photography, often called oblique photography, is the type that as still photographers we are concerned with.

629. Explain principles and procedures used in aerial photography.

The following is a brief survey of problems that aerial photography can present.

Haze. Haze is always present to some degree in

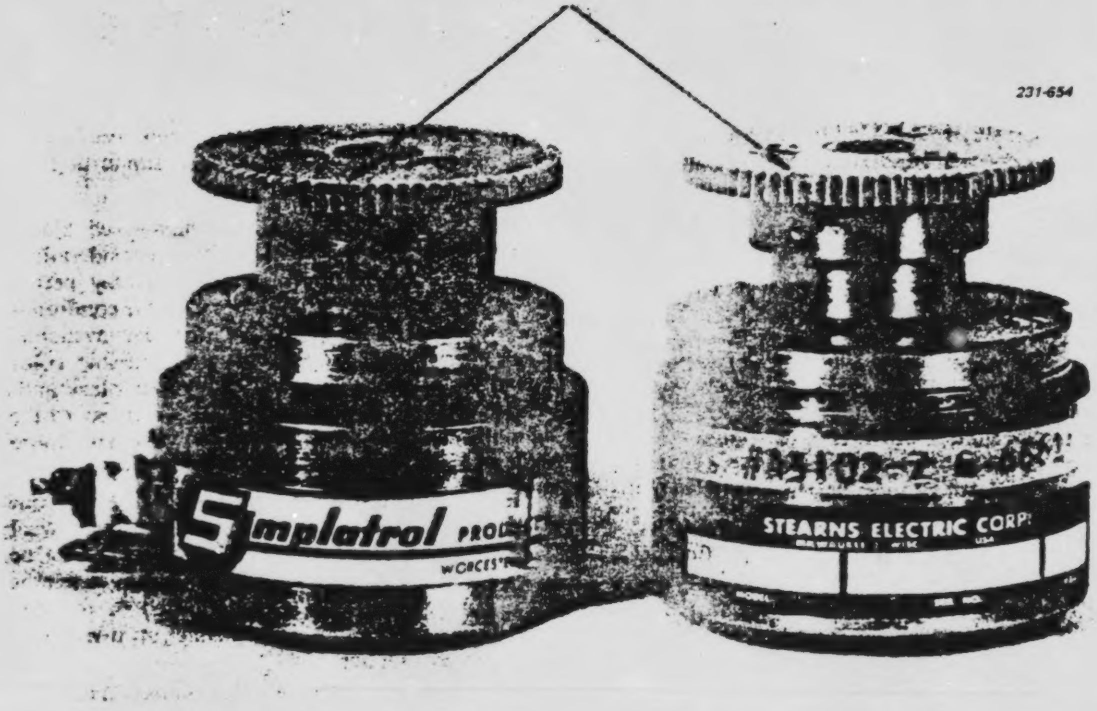


Figure 3-19. Deficiency report photograph showing defect in detail.

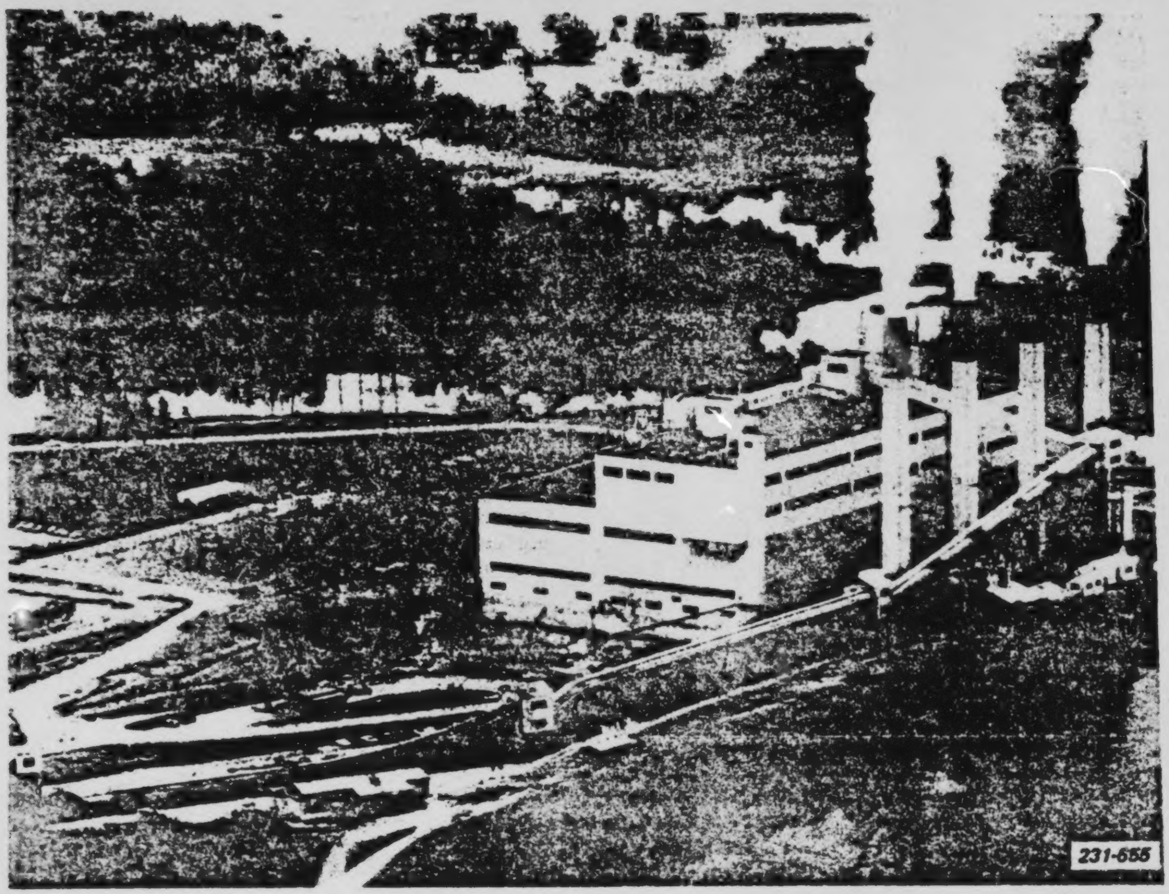


Figure 3-20. Low-oblique aerial photograph.

aerial photographs. Much haze lies in the ultraviolet portion of the spectrum and has a greater effect on film than is apparent to the eye when viewing a scene. Haze causes an overall bluish cast in color photographs and lowers the contrast in both black-and-white and color work.

There are several ways of minimizing the effects of haze. Haze registers greatest when the aerial subject is backlighted and registers least when the camera is pointed away from the sun. However, with the sun behind the camera the resulting shadowless front lighting of the subject provides little modeling. For this reason, a compromise with some cross-lighting is best. Also filters can be most helpful in reducing the effect of haze.

Filters to use with black-and-white films include a deep yellow filter or, if the haze is particularly bad, a red filter. With color films a haze filter would be a logical choice.

Motion. Motion creates several factors to be considered. These include the speed of the aircraft relative to the subject, the jolting effect of the weather, and the vibration of the plane. All of these must be overcome to insure a sharp image. Techniques include using a high shutter speed and not supporting the camera with any part of the plane.

Film Selection. Conventional high-speed black-and-white films should receive first consideration. Ideal weather and lighting conditions may permit using medium-speed films, whereas adverse conditions could require using the highest speed films available. For greater haze cutting, black-and-white and color infrared films are superior to standard black-and-white or color emulsions. Their ability to record the longest wavelengths will result in shots with more detail and contrast.

Mission Planning. Know the objectives of your aerial project. Find out what you need to show, what product is required, and when the product must be available. This information will help you detemine what camera and films are best suited to the job, whether you can wait for ideal weather or, if you must fly the project sooner.

Study the location of your aerial subject. Determine what time of day will present the best lighting for the subject, from what direction you will probably have

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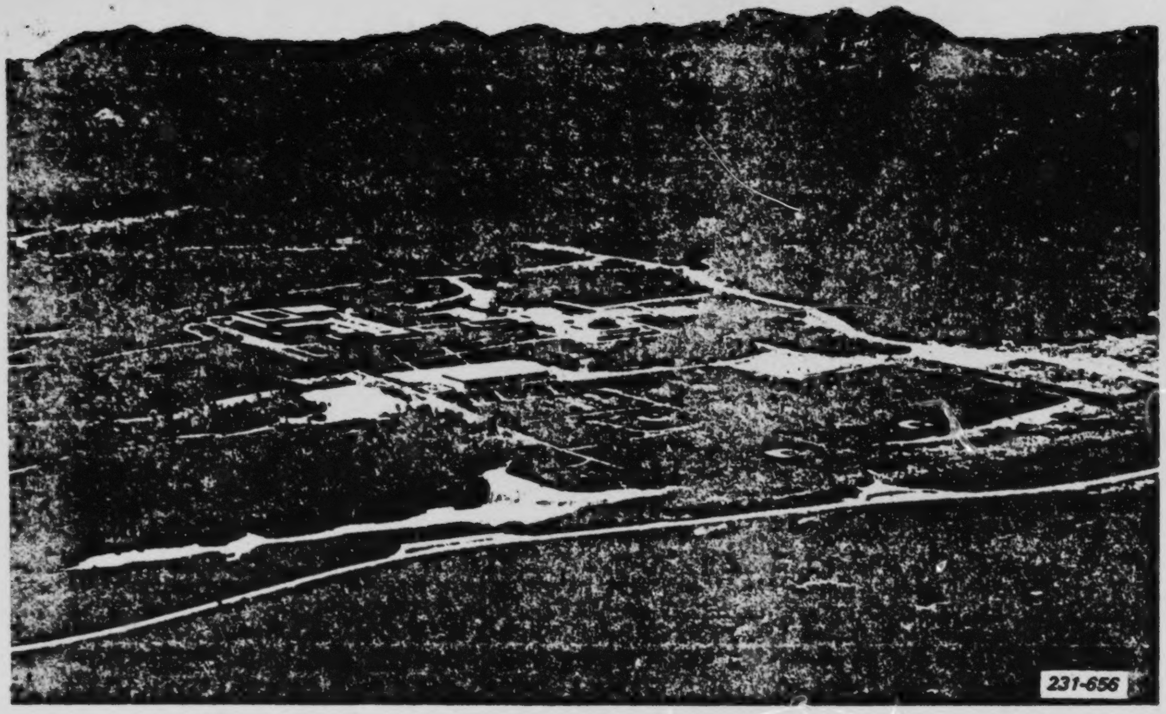


Figure 3-21. High-oblique aerial photograph.

the best view, approximately what altitude will be best, and what terrain features or navigational hazards are in the general areas. Also, check for any other aerial assignments you can complete enroute or nearby.

Good weather conditions for aerial photography are generally considered to be clear with 10 to 15 miles-per-hour winds (to help blow off smoke and smog) and visibility of 15 miles or more. Minimum conditions are generally considered to be scattered clouds and about 10-mile visibility. Less clear conditions may yield photos of some value for record or study purposes, but results are likely to be of marginal quality. If weather conditions are poor, shoot a low oblique from fairly low altitudes. This helps minimize the effects of smoke and haze.

The types of aircraft you will use depend mostly upon which models are available. A high-wing, fairly slow plane is fine. Many of these have large windows that open and provide a good area for viewing and photographing the subject. Often, low-winged aircraft do not have a window that can be opened and tend to have higher minimum flying speeds.

A helicopter can offer several advantages for aerial photography. It can give an unobstructed view, fly low altitudes more safely, concentrate more time over a small area, and get in and out of places that are inaccessible to fixed wing aircraft.

A hovering helicopter, however, does not present the best aerial-photo platform. While hovering, a helicopter sets up fairly severe vibrations that contribute to unsharp pictures, and extended hovering is tough on both the craft and the pilot. The engine tends to overheat, and the pilot is busier than when he has additional lift and better control with forward speed.

Communication between the pilot and the cameraman is essential. Prior to takeoff, try to brief the pilot as fully as possible on the project. Study maps of the site (air, road, topographic) when available. Try to determine some landmarks that can easily be seen from the air. Things look different from above and it is easy to become disoriented. With your maps, your information, and your pilot's experience, determine whether there are any navigational hazards in the area. Decide approximately what safe or legal altitude will yield best results. Based on your study of the subject, advise the pilot of the primary and secondary angles you prefer to shoot.

Most military aircraft have an intercom system with headsets and microphone for in-flight communication. Otherwise, establish a set of hand signals with which you can help direct your pilot. His viewpoint is considerably different from yours, and he will be trying to put you in the best position. As a result, he may not have a very good view of the subject himself.

Basic Types of Oblique Photographs. As a cameraman taking aerial oblique photographs, you are not concerned with rigid specifications of camera altitude or positions as in the case of photogrammetry. By using a hand-held camera and directing the pilot into position, you can establish the relationship of the camera to the subject. Two general categories govern the types of oblique aerial photography: low and high oblique.

Low oblique aerial photographs provide the most tolerance of camera angles. From a near-vertical position and coverage to just below the horizon is considered the range for this type of aerial photograph. This means that the longitudinal axis of the camera is directed away from 5 to 65 degrees from the vertical. Actually, the ideal angle for a good study of the target and surrounding area is about 45 degrees. (See fig. 3-20.)

High obliques include some sky and horizon. This may vary from 10 to 50 percent of the format coverage; about 25 percent is average. More coverage of terrain is accomplished and orientation is one of several uses for this type of aerial photograph. (See fig. 3-21.)

Exercises (629):

1. What effect does haze have on both black-and-white and color film?

2. What type of lighting provides modeling and cuts down the effect of haze?

3. What type of black-and-white film will provide the most haze cutting power?

4. Name two techniques that should be used to cut down the effect of aircraft motion.

5. What type of weather conditions are good for aerial photography?

6. Identify the type of plane that is best suited for aerial photography.

7. What is the basic difference between a low or high oblique photograph?

630. State a solution to problems related to making aerial exposures.

Exposure Factors. When it is necessary to determine proper aerial exposures, try to take the following factors into consideration: (1) use a fast shutter speed, (2) use the minimum amount of filtration to penetrate the haze, (3) try to take photographs when clouds do not interfere with the target area, (4) keep camera motion to a minimum, (5) plan your photography so that the sun is not directly behind the camera, (6) maintain records to remind yourself which exposures with which materials have been proved to produce the best results, (7) avoid photographing through turbulent air, whenever possible, and (8) use an exposure meter, but only if you can interpret the meter readings so that they produce the correct exposure.

Let us elaborate on a couple of these points. Due to the presence of haze, an aerial meter-reading may be inaccurate. The average between a reading taken on the ground and one taken in the air is suggested. For instance, if the ground reading is f/8 and the aerial reading is f/16, use f/11. Another suggestion is to use one stop less exposure than your ground reading. Gaining experience is your most dependable procedure.

Fast shutter speeds are advised to help solve the significant problem of stopping image blur. Focus is constant and set at infinity. Since you have no problem with depth of field in aerial photography, you may often use a wide open aperture setting. However, you should use the critical aperture for maximum sharpness when the other conditions of light, film sensitivity, and shutter speeds permit.

While taking aerial photographs, keep the camera from touching any part of the aircraft. If the camera is in contact with the craft, it picks up engine vibrations; and even with a fast shutter speed, you get unsharp pictures. Also, as a shock absorber for vibration, keep your body, from the waist up, from touching the aircraft.

It is a good idea to have the pilot fly a gentle arc around the subject at the anticipated altitude, so that you can check the view and the modeling effect of the shadows from various positions. Use prearranged signals to direct the pilot in placing the aircraft in the most desirous position.

Best results from either a fixed-wing craft or a helicopter are usually achieved when the pilot reduces throttle, banks the aircraft slightly, and slips it toward the subject. This keeps down engine vibrations and minimizes image motion by reducing forward motion.

Most pilots who have flown photo assignments are aware of the advantages of this technique, but most likely you will want to discuss it with your pilot in advance. With low-winged craft, you are in a good shooting position on a banked slip. With high-winged craft, be careful that the wing does not get low enough to get into the field of view; if you shoot a little toward the rear, it will help to avoid the wing tip.

If you are working from a particularly low altitude, the side-slip technique cannot be used safely because the aircraft needs room to recover. From very low altitudes, it is usually best to reduce throttle and apply several degrees of flap to reduce the airspeed even more. How much, if any, airspeed can be cut down depends on several factors. For example, under gusty conditions, the flaps may cause too much buffeting and could contribute more to unsharpness than would using increased speed without flaps.

Exercises (630):

1. If your ground exposure is f/11, what will probably be your aerial exposure?

2. Why isn't depth of field a problem in aerial photography?

3. How should the pilot normally fly the plane when approaching the target?

CHAPTER 4

Operating Photographic Laboratory Equipment

THERE WAS A TIME when it was possible to process all Air Force sensitized materials with hand-operated equipment. As the volume of prints, negative material, and motion picture film became too great for that type of processing, the equipment was gradually converted to power operation. As the requirements of time and quality have grown more stringent, the constant effort to get more work done with fewer technicians has brought the automatic processing machine into use. There are instances when thousands of feet of sensitized material must be processed in a single 24-hour period. The quality of the finished product must not be sacrificed, and the work must be done without additional technicians.

The newer developing units are neither fast nor economical for small jobs; they were not designed for this purpose. Careful scheduling of workloads is necessary to make them pay off. When properly scheduled and used, these machines save the Air Force considerable time and money.

4-1. Continuous Processing Machines

The primary function of the processing machine is to transport film or paper through the various chemical solutions, allowing the proper treatment time in each solution. The processing machine must provide the proper processing over the material's entire length and across its total width, and it must do this job in a reproducible and consistent manner from one roll to another. In order to do all this, mechanical elements for controlling the processing must be adjustable so that they can be changed as the need arises. In addition, the chemical makeup of each processing solution must be under constant control so that it can be altered as necessary.

631. Explain principles of machine processing operation.

Controllable Factors of Machine Operation. In conventional tray or tank processing you always consider time, temperature, and agitation. These factors must also be considered in machine processing. In addition to these variables, there are also considerations that are specifically applicable to machine operation. With many machines you must think of the recirculation of solutions, solution replenishment, carryover of solutions from one tank to another, and solution filtration.

Machine speed. The time that the solutions act on the sensitized material is determined by the speed at which the machine transports the film or paper and the number of feet of material that accumulates in a specific tank. In most machines the speed is controlled by a knob and indicated on a dial which shows the number of feet of material passing through the machine per minute. If, for example, the speed control knob is set at 10 feet per minute and if a certain portion of the material takes 3 minutes to go from a point where it enters the developing tank to a point where it leaves the developing tank, we can say that 3 minutes of development results from running the machine at 10 feet per minute. Feet per minute, therefore, is used exactly like development time is used in conventional hand processing.

Temperature. One of the most critical elements in the control of the photographic process is temperature. The speed of chemical reaction increases as the temperature of a solution is raised and decreases as the temperature is lowered. In most hand processing of black and white film we use a standardized temperature of 68° F. Machine temperatures are often much higher because of the high operating speeds. Temperature control is critical and must be maintained at a predetermined level to insure consistent results. Most machines are automated in this respect and contain both a refrigeration unit and a heating unit which operate to maintain a constant solution temperature. The control panel of a processing machine generally contains a temperature indicator and a control knob to adjust the temperature.

Agitation. Agitation is an important factor that controls the density and contrast of the finished product. Through experience you know this is especially true in tray processing where the degree of agitation makes considerable difference in total development. Automatic processing machines must also agitate the sensitized material or solutions during processing. Agitation is essential to insure a continual fresh supply of chemical solution to the emulsion surface. Insufficient agitation can cause uneven development and fixation.

There are many devices, besides the simple action of the film moving through the machine, for providing controlled agitation. The following are most often used:

a. Gaseous burst agitation provides intermittent bursts of a photographically inert gas (such as nitrogen), which is released from the bottom of the tanks and rises up through the processing solution.

b. Tank turbulation or solution recirculation provides rapid movement of large volumes of solution through the tank.

c. Submerged jet or spray heads within a tank direct streams of solution onto the surface of the emulsion.

Recirculation. Many machines have recirculation systems that pump solution chemicals out of their respective tanks and back again. Recirculation is done to provide filtration to remove contaminants from the solution, maintenance of temperature, or as an aid to agitation. Such systems add to the mechanical complexity of the machine and must be properly maintained.

Replenishment. During processing the various chemical solutions are used up at various rates. In addition, there are certain reaction byproducts that form in each tank. For example, bromide is a reaction byproduct of development and, therefore, builds up in the developer solution. There is also a certain amount of carryover of solution from one tank to another.

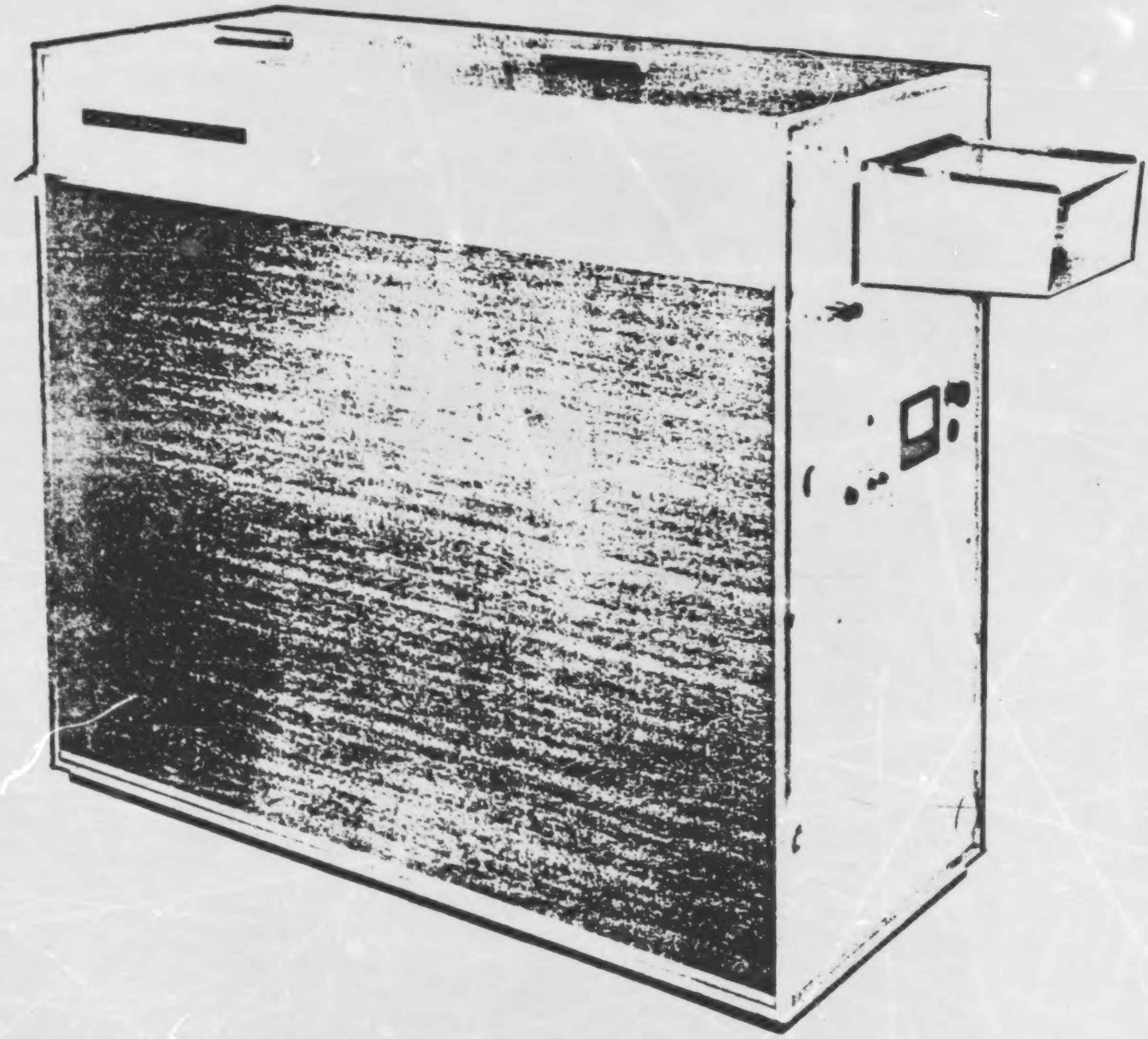


Figure 4-1. Versamat 11C-MW.

Therefore, there is a continuous change in solution strength and purity.

To maintain consistent processing, fresh chemicals are pumped from storage tanks into the various machine tanks to provide the necessary replenishment. The solutions used for replenishment must each be of a specific composition so that each will properly replace the used chemicals of each solution in the correct proportion. The replenisher solution must also control the content of the solution so that there will be no buildup of the reaction byproducts which have been formed through the process of development. Finally, there is a certain amount of fluid loss which must be compensated for by replenishment.

Replenisher formulas and the rate at which replenishers are added to a solution depend on the type of machine being used, the material being processed, the chemical formula of the original, agitation, temperature, and speed. Your machine will have controls that you set to meter the replenishment flow.

Drying. Most automated processing machines have a drying cabinet. After the material is developed, fixed, and washed, it continues through the machine into the drying cabinet. It emerges from the cabinet in a dry condition and is then spooled onto a reel or collected.

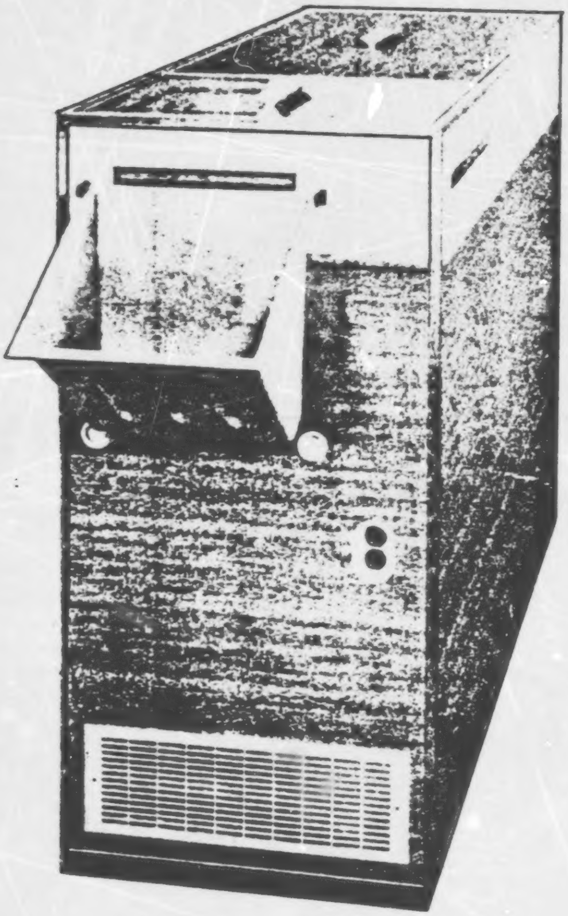


Figure 4-2. Versamat 11C-MW—take-up end.

The drying cabinet is much more than a heated container for the sensitized material. In a majority of the machines, the temperature and the humidity of the cabinet are both controlled so that the completely processed material will have the desired properties. Too little drying causes the emulsion to be tacky, whereas too much drying results in excessive curl and brittleness. Both the temperature and relative humidity of the air supplied to the drying cabinet must be carefully controlled and adjusted for the speed at which the machine is operating.

Due to the several factors involved in machine processing, it is important that you learn all you can about the machine you are operating. Only in this way can you determine the cause of any problem you may have.

Exercises (631):

1. How does machine speed determine developing time?

2. Why are machine processing temperatures higher than in hand processing?

3. Why is agitation important?

4. Why would a machine have a developer recirculation system?

5. Why is replenishment necessary?

6. Too little drying of film will cause what problem?

632. Complete statements on the description and operation of the Versamat 11C-MW.

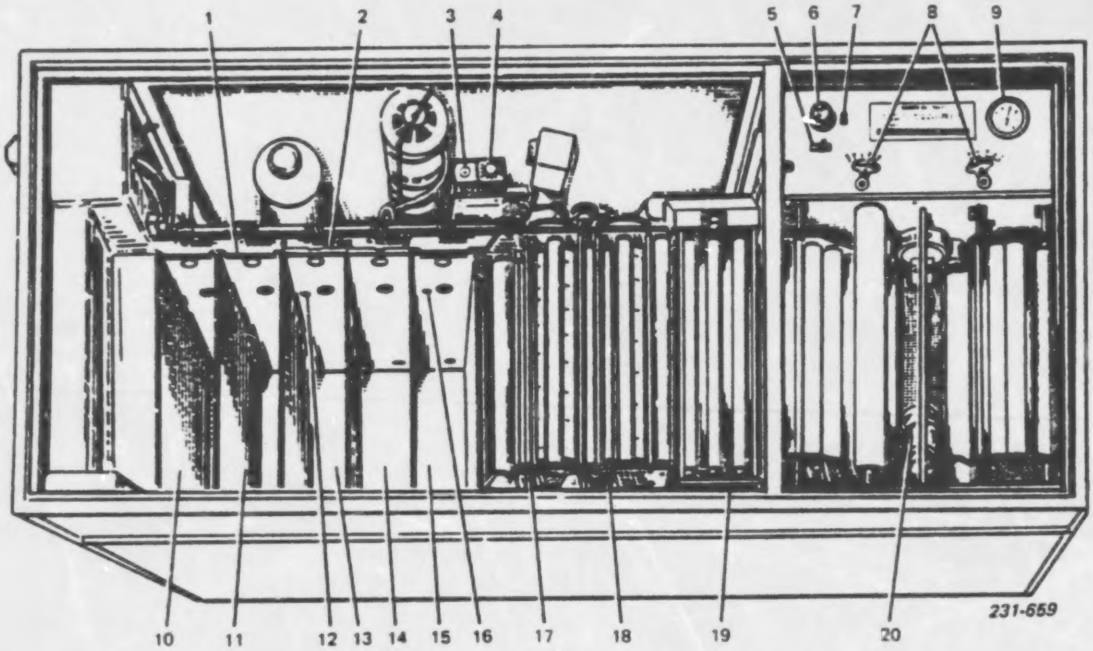
Versamat 11C-MW. In many base laboratories, varying amounts of film of different sizes must be processed. Cut film, film packs, and roll film ranging from 16 millimeters up to $9^{1}/_{2}$ inches in width may be needed to meet mission requirements. A processor to meet these demands is the Kodak Versamat 11C-MW (see figs. 4-1, 4-2, and 4-3). Not only does the machine have the above capability, but it can process cut film in any size from 4 by 5 inches to 11 by 14 inches and paper prints. All processing can be done to speeds of up to 25 feet per minute.

General Description. The processor is entirely automatic. Film is transported through the various solutions, washed and dried. The processor is normally installed in the wall between a darkroom and a normally lighted room. The feed end of the machine is in the darkroom, and the processing, drying, and takeup end can be in a lighted room.

The heart of the processor is the transport system which is made up of seven transport racks and eight crossover assemblies. Each transport rack consists of a series of chain-driven rollers mounted in a staggered path (see fig. 4-4). As the rollers rotate, the film is conveyed from roller to roller throughout the system. When the film reaches the bottom of each rack, it is turned 180° to complete its course through the rack by a turnaround assembly mounted at the bottom of each rack. When the film reaches the top of a rack, it enters a crossover assembly which conveys it to the next rack. There are eight crossover assemblies: one for the entrance to the first rack, one between each of the seven racks, and one at the exit of the last rack. To insure proper transport of roll film as well as certain cut and pack films, it is necessary to use a stiffening tab (bullit), such as a sheet of film or clear acetate. The tab must be cut seven inches long and two inches or more wide and is butt spliced to the film.

During processing the film is completely immersed in the solutions. Spray washing cleans the film before it enters the drying cabinet. As the film enters the drying cabinet it passes through a separate squeegee rack, which removes any excess water. The basic film path is shown in figure 4-5.

As film is drying, the air in the dry box becomes water saturated. To maintain an adequate operating speed, this water-saturated air is piped away from the processing area through a duct. Thus, drying is speeded up. The dryer section is equipped with two adjustable air dampers. Each damper is positioned by a separate damper control knob. The type of film



1. OVERFLOW
2. WEIR BLOCK
3. DEV THERMOSTAT PILOT LAMP
4. DEVELOPER THERMOSTAT
5. DRYER FLOOD LIGHT SWITCH
6. DRYER THERMOSTAT
7. DRYER THERMOSTAT PILOT LAMP
8. DAMPER CONTROL KNOBS
9. DRYER TEMPERATURE GAUGE
10. NUMBER 1 DEVELOPER TANK
11. NUMBER 2 DEVELOPER TANK
12. FIXER INLET (A TYPE CHEMISTRY)
13. NUMBER 1 FIXER TANK
14. NUMBER 2 FIXER TANK
15. NUMBER 3 FIXER TANK
16. FIXER INLET (B TYPE CHEMISTRY)
17. NUMBER 1 WASH TANK WITH CROSSOVER
18. NUMBER 2 WASH TANK WITH CROSSOVER
19. SQUEEGEE–DRYER CROSSOVER
20. DRYER FLOOD LIGHT

Figure 4-3. Processing and dryer controls of Versamat 11C-MW.

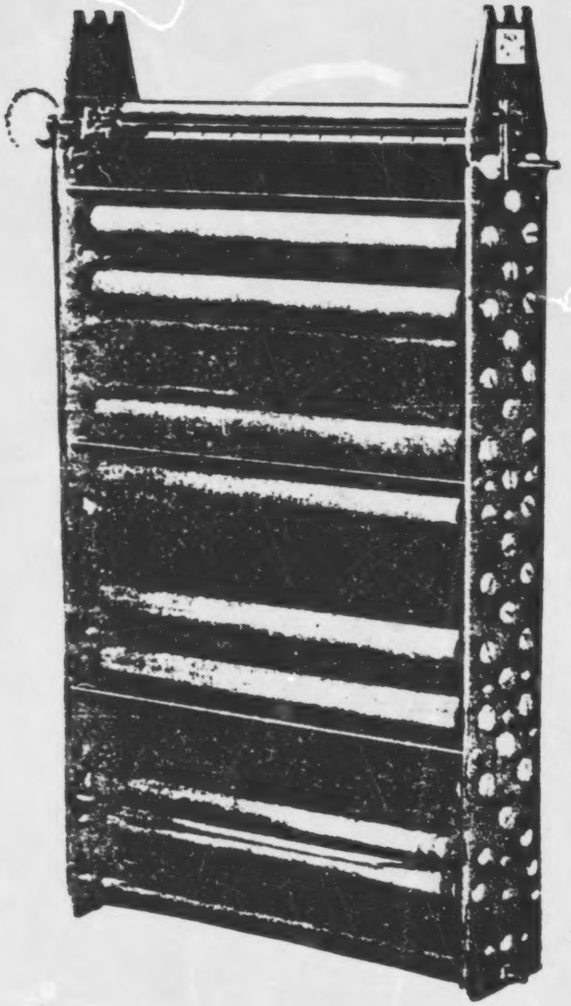


Figure 4-4. Transport rack.

being processed, the ambient conditions of the air in the laboratory, and the transport speed govern the setting of the dampers. In addition to the dampers, there is a control that operates the dryer blower. The dryer heaters operate according to the demands of the dryer thermostat. A pilot light indicator shows when the dryer heaters are operating.

Electrical Control Panel. The main control panel (refer to fig. 4-6) is located at the feed end of the machine. Note that there is not a main power switch. The electrical power supply is supplied through a wall-mounted, off-on switch. When this switch is on, all components are energized.

Dryer fan switch. This switch operates the dryer blower and heater when the dryer thermostat calls for heat. The dryer pilot lamp lights when the heaters are operating.

Main drive switch. This switch controls power application to the main drive motor, which operates the film transport roller system. When you turn this switch on, there will be a 3-second delay before the transport machine is activated. This delay permits the drive motor to get up to speed before the load of the transport mechanism is applied.

Replenisher pump switch. This switch controls the replenisher pump with three positions: MANUAL, OFF, and AUTOMATIC. In the AUTO position, the replenisher pump operates only when film is passing through the feed detection rollers located in the feed end. This switch must be in the AUTO position when you are processing sheet film. When the switch is in the MANUAL position, the pump stays in continuous operation. MANUAL is used for processing continuous lengths of thin-base aerial roll film. The pilot light on the panel lights only when the switch is on MANUAL.

NOTE: The fixer replenishment system is set up differently depending on the type of developer that is used. Figures 4-7 and 4-8 show the arrangement for Type A (aerial) and Type B (commercial).

Developer recirculating pump switch. This switch energizes the developer heater and the recirculating pump. The thermostatically controlled heater brings the developer up to the selected temperature. This pump recirculates the developer through the first two tanks (see fig. 4-9).

Speed indicator light switch. This switch illuminates the speed indicator.

Speed indicator. This indicator shows the speed of film travel through the machine. It is calibrated in feet per minute up to 25 feet.

Speed control knob. This knob increases or decreases the speed of film transport.

Accessory outlets. The machine has accessory outlets, one at the feed end (operates in conjunction with a timer circuit or for a safelight) and one at the dryer end (connects a roll takeup adapter or static eliminator).

Preoperation Procedures. Before you check the machine for proper operation, you must know the type of product to be processed (sheet or roll film). If it is sheet film, you will need a feed tray and film bin at the dryer end. If it is roll film, you will need a roll feed adapter, an idler roller, and the roll takeup adapter. The following procedural steps are now accomplished, assuming that the electrical and plumbing hookups have been made by maintenance personnel.

(1) Flush all the racks and crossover assemblies with fresh water. Wipe each tank with a damp sponge.

(2) Close all five drain valves.

(3) Verify that all solutions have been mixed and are in their appropriate containers.

(4) Install the No. 1 rack in the first developer tank.

(5) Fill the first and second tanks to the fill line visible in the second tank.

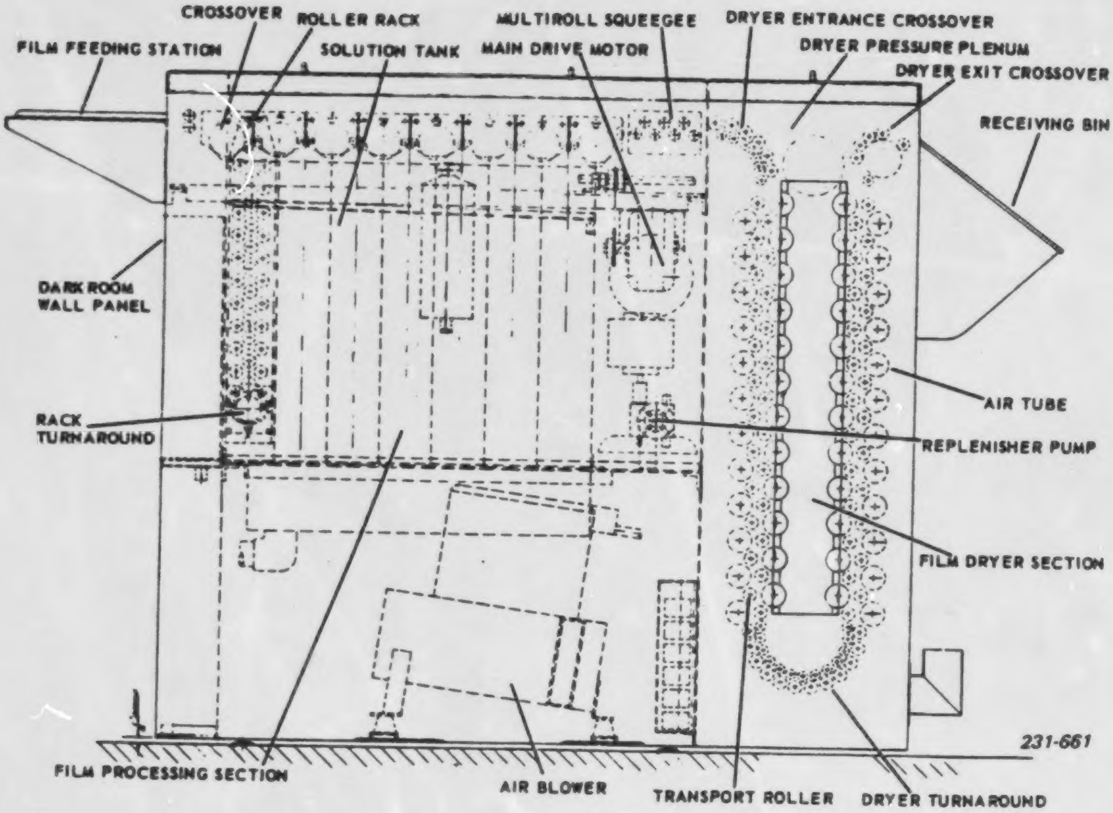
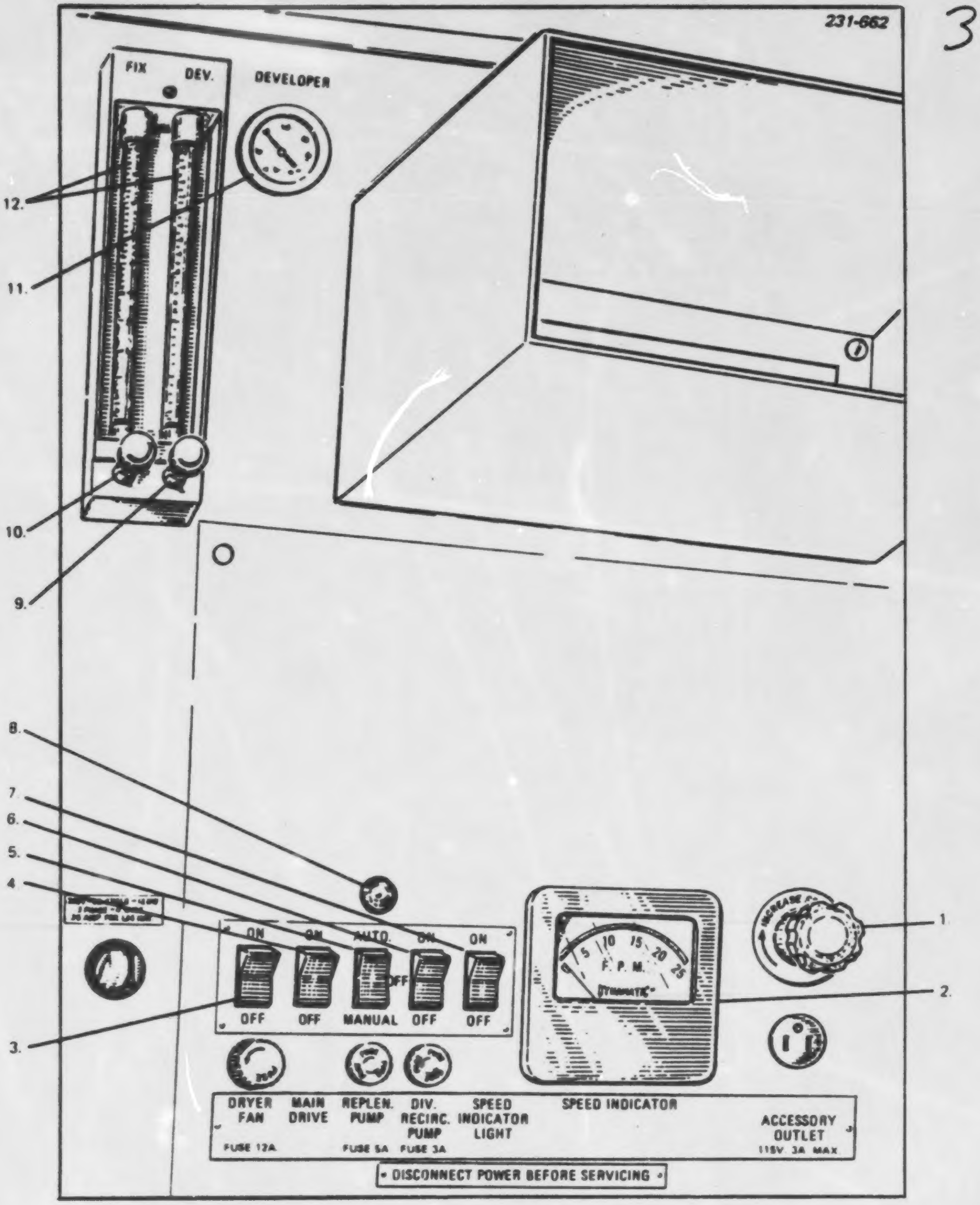
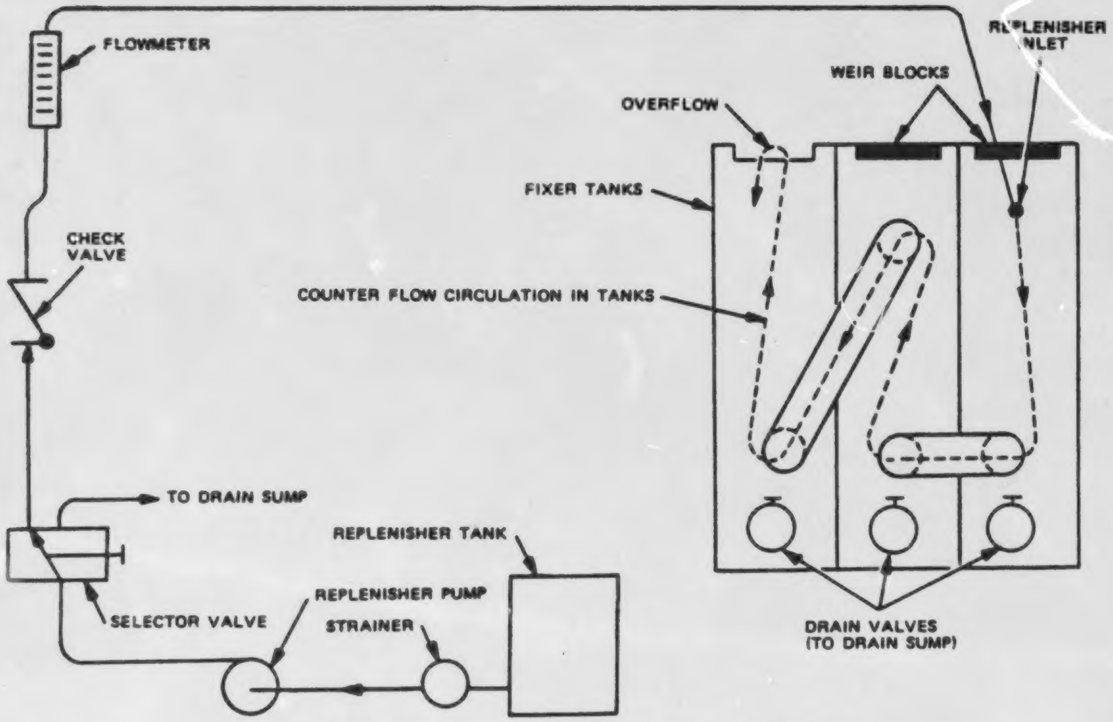


Figure 4-5. Basic film path.



1 SPEED CONTROL KNOB
2 SPEED INDICATOR
3 DRYER FAN SWITCH
4. MAIN DRIVE SWITCH
5. REPLEN. PUMP SWITCH
6. DEV. RECIRC. PUMP SWITCH
7. SPEED INDICATOR LIGHT SWITCH
8. INDICATOR LAMP–REPLEN. PUMPS
9. FLOWMETER CONTROL VALVE– DEV
10. FLOWMETER CONTROL VALVE– FIX
11. TEMPERATURE GAUGE– DEV.
12. FLOWMETER TUBES

Figure 4-6. Main control panel.



FIXER REPLENISHER FOR AERIAL–TYPE FILM CHEMISTRY

	AERIAL–TYPE	COMMERCIAL–TYPE
CHEMICALS	TYPE A	MX–641–1 (TYPE B)
WEIR BLOCKS	NUMBER 2 & 3 FIXER TANKS	NUMBER 1 & 2 FIXER TANKS
FIXER INTAKE	NUMBER 3 FIXER TANK	NUMBER 1 FIXER TANK

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Figure 4-7. Fixer replenishment flow—type A chemistry.

(6) Carefully lower the No. 2 rack in the second developer tank.

(7) Place the splash guard between the second developer tank and the first fixer tank (to prevent developer contamination).

(8) Install the No. 3 rack in the fixer tank. Fill fixer tanks Nos. 3, 4, and 5 with fixer solution to the fill lines shown in tanks 4 and 5. Carefully lower racks 4 and 5 into their respective tanks.

(9) Install racks 6 and 7 in their respective tanks. Make sure that all racks are properly seated and then remove the splash guard.

(10) Turn on the main electrical power switch (wall switch).

(11) Open both flowmeter control valves. Press the replenisher pump switch to the MANUAL position and see that the solutions show proper indication in the developer and fixer flowmeter tubes.

(12) Change the replenisher pump switch to the AUTO position. Check the replenisher microswitch to be sure that it operates when a single thickness of film is inserted between the detector rollers. (Call maintenance if necessary.)

(13) Check the two thickness detection microswitches, which sense more than one film thickness. Insert *two* thicknesses of film about two inches wide at each side (in turn) of the feed tray. A warning buzzer should sound. If there is no warning, call maintenance to adjust the microswitches (see fig. 4-10).

(14) Check the squareness of the feed tray. Place an 8- by 10-inch sheet film on the feed tray and push it forward until it is in contact and square with the feed and detector rollers. Square the film edge with the side guides of the tray after loosening the wing nuts; then tighten the nuts.

(15) Install the eight crossover assemblies in the tank section. Start at the feed end and work toward the dryer. These assemblies transport the film from one rack to another.

(16) Install the squeegee assembly.

(17) Replace all access panels and attach roll film adapter mechanisms if necessary.

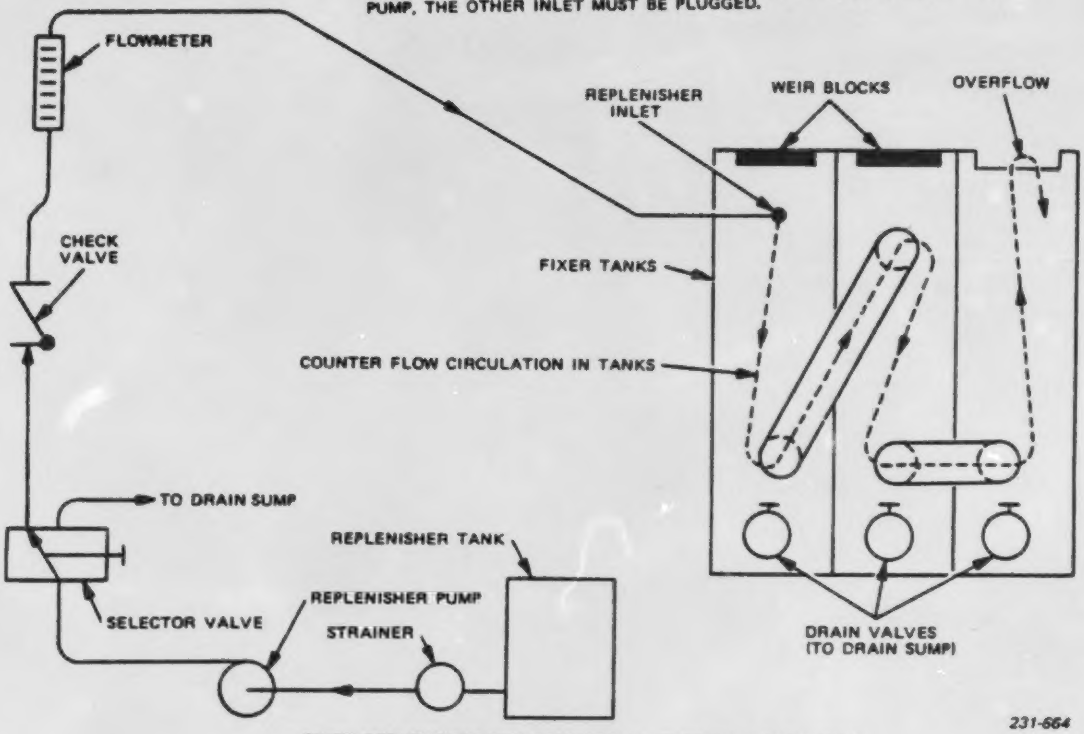
(18) Turn on hot and cold water and adjust the mixing valve to a temperature 5°F less than the recommended developer temperature.

(19) Turn on all switches.

(20) Allow 5 to 10 minutes for the developer to come up to temperature.

NOTE: The above steps are generalized. Refer to

CAUTION: A CAP IS PROVIDED TO PLUG THE FIXER INLET CONNECTION NOT IN USE. WHEN THE PROPER INLET IS CONNECTED TO THE FIXER REPLENISHMENT PUMP, THE OTHER INLET MUST BE PLUGGED.



FIXER REPLENISHER FOR COMMERCIAL–TYPE FILM CHEMISTRY

Figure 4-8. Fixer replenishment flow—type B chemistry.

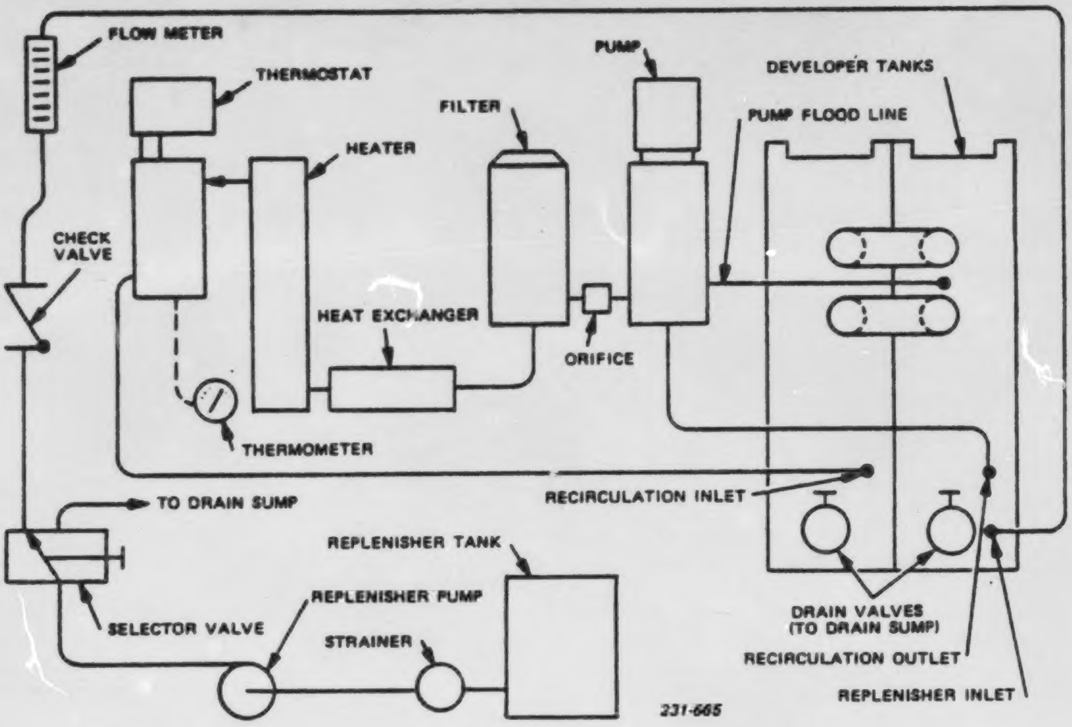


Figure 4-9. Developer recirculation flow.

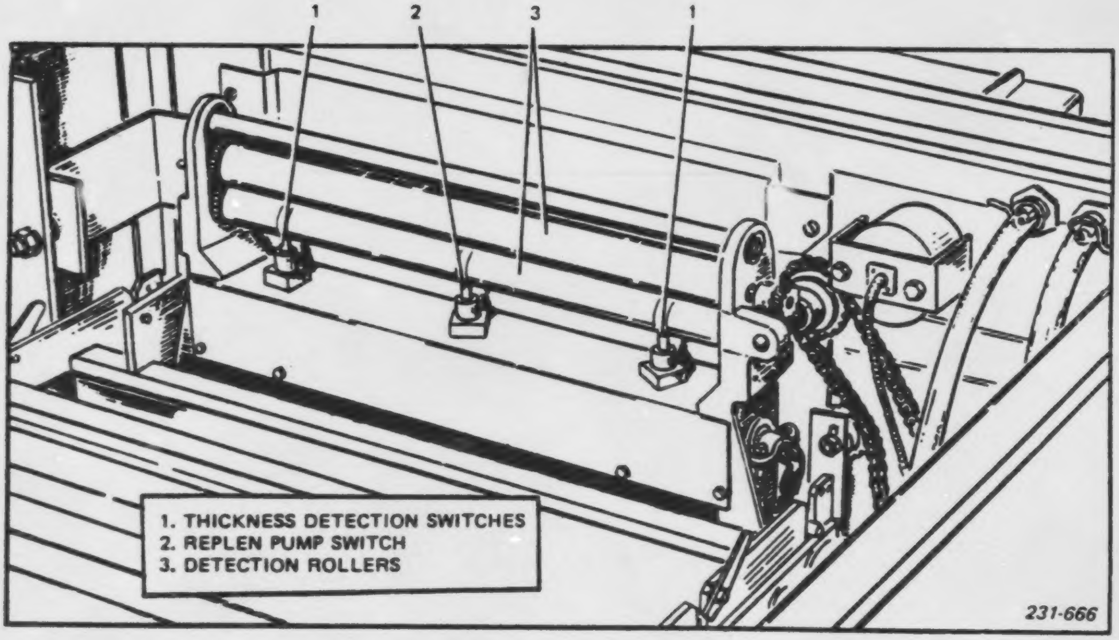


Figure 4-10. Detection switches, top view.

an appropriate technical manual or manufacturer's handbook for exact procedures and specific model requirements.

Operation. This processing system is relatively simple to put into operation, but there are certain critical factors that you must watch to assure success. It is imperative that you carefully follow the manufacturer's recommendations regarding cleanliness, chemistry, operating temperatures, and replenishment. If all factors are carefully monitored, then processing is reduced to feeding film in the front and collecting it at the other end.

Consider the following steps when you are processing film:

(1) Turn on the main (wall-mounted) power-source switch and outside water source.

(2) Turn on the dryer fan, main drive, and developer recirculating pump switches. If you are processing sheet film, press the replenishment pump switch to AUTO. If you are processing continuous lengths of thin base roll film, press this switch to MANUAL.

(3) Set the developer and wash temperatures.

(4) Set your developer and fixer replenishment rates by turning the appropriate flowmeter control knobs.

(5) After all temperatures have been reached, you can set your transport speed and begin processing.

(6) Prior to processing mission film, you should feed test film emulsion up into the processor and carefully monitor film movement through all sections. The film should then be checked for dirt and scratches which would indicate damaged, corroded, or dirty rollers.

(7) Once all is set you can start feeding your mission film emulsion side up. Be sure that the film edge (sheet film) is square with the side edge of the feed tray; then advance the film until it is picked up by the rotating detection rollers. Do not feed films less than 5 inches long. Figure 4-11 shows typical feed configuration for sheet film. Narrow films are fed side by side to avoid overreplenishment.

(8) Remember, when you are processing narrow roll film (or thin sheet film), splice a stiffening tab (bullit) made from leader material to the leading edge of the film. The butt splice is held together with Mylar tape which is impervious to chemicals. The purpose of the bullit is to guide the film through the machine.

(9) Once you have completed your processing you can shut down the machine by following these steps: Decrease the machine speed to 5 feet per minute; turn the dryer thermostat OFF, remove the top cover and side covers of the processor; turn the replenisher switch OFF; turn the developer recirculation switch OFF; turn the dryer fan OFF; turn the water OFF; remove and clean all crossovers using warm water not above 120 degrees; wipe down the crossover correctly; replace the side and top cover and turn OFF the main power.

NOTE: The key to consistent operation of any piece of equipment is to follow directions. Learn the procedures set down by your laboratory and follow them. If you have questions, check with your supervisor. Remember, too, the need for SAFETY. Always remove rings and watches when operating equipment. You should wear any protective equipment that is prescribed.

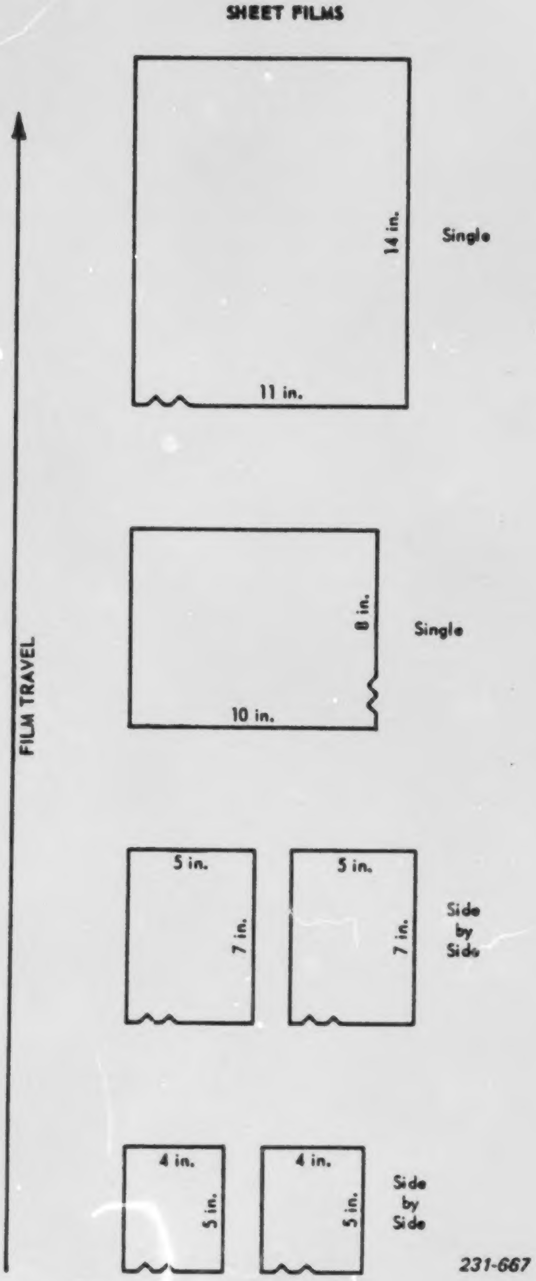


Figure 4-11. Feeding sheet film.

Exercise (632):

1. Complete the following statements on the description and operation of the Versamat 11C-MW.
   a. The Versamat 11C-MW transport system has ________ crossovers and ________ racks.
   b. The Versamat has ________ tanks; ________ for developer, ________ for fix, and ________ for wash.
   c. ________ solution is recirculated within the Versamat.
   d. The Versamat can process roll film up to ________ inches in width and sheet film up to ________ by ________ inches.
   e. When processing roll film, a ________ is spliced to the film to act as a guide.
   f. The Versamat can be operated at speeds up to ________ feet per minute.
   g. ________ replenishment is used when processing sheet films.
   h. The pilot light on the panel lights when the replenishment switch is on ________.
   i. The replenishment inlet in the ________ fixing tank is used when processing with Type A chemistry.
   j. Replenishment rates are set by using the ________.
   k. Film less than ________ inches in length should not be fed into the machine.
   l. You should not wear ________ and ________ when processing.

633. State or explain principles of operator maintenance on the Versamat 11C-MW.

Operator Maintenance. Most of your maintenance is concerned with keeping the processor clean. This is a day-to-day procedure for many parts of the machine. Each time the processor is shut down, you must remove all crossover assemblies and rinse them with warm water. If any deposits have formed, use a soft brush to remove them. Be sure you handle the crossovers with care. Wipe all rack rollers above the solution level. The feed rollers of the entrance roller assembly should also be wiped off. Turn off all machine electrical switches and the main power switch. It is advisable to prop open the processing and dryer section covers to vent chemical fumes. Also, turn off the water supply.

After a week's operation, the cleaning procedure is more involved than for overnight shutdown. The following procedure is suggested:

(1) Remove, wash with water, and wipe off all rollers of the crossover assemblies.

(2) Check the tension of the rack chains. Any roller hesitation indicates a loose chain.

(3) Remove the roller racks. Use the splash guard when you pull the fixer rack to avoid contaminating the developer. Wash all racks with running water that is not warmer than 120°F. (This is because the rollers are covered with polyethylene which would be damaged by high temperatures.) Be sure to clean all chemical deposits on the sides of the racks, around gears, on the chain tighteners, etc.

(4) Rotate the rollers by hand and make sure they turn freely. Adjust chain tighteners if necessary.

(5) Check all racks to make sure they are not twisted. To do this, place each rack on a flat surface. Any twist will be apparent.

(6) Turn on the recirculation pumps and watch for surface turbulation in the solutions in the tanks to verify pump operation.

(7) Examine the solutions in the tanks for clarity and the presence of foreign particles.

(8) Reinstall the racks and crossovers. Check all the gears to make sure they are properly seated.

(9) Check the dryer entrance crossover, the exit crossover, and the multiroll squeegee assembly for proper seating.

(10) Inspect the dryer air tubes. If the slits are clogged, inform maintenance personnel. Also, make sure that the air intake screen is clear of obstructions.

Daily and weekly maintenance, covered up to this point, is largely your job. In addition, it is advisable to establish a regular periodic maintenance program. Such a program is accomplished by maintenance personnel; and it covers lubrication, signs of wear, parts replacement, maladjustments, etc. You should know when a machine is due for maintenance because it will be out of service. Also, you should keep a log of minor difficulties so that they can be corrected during scheduled maintenance.

With proper replenishment, Versamat solutions can last almost indefinitely. On a periodic basis, however, it is usually necessary to thoroughly clean the machine and perform preventive maintenance at the same time. The developer should be discarded at this time.

A complete cleaning of the tanks may then be your job. Cleaning is expedited by a cleaner such as the manufacturer-recommended Kodak Developer System Cleaner. Do *not* use this cleaner in the fixer system.

CAUTION: The cleaner contains sulfamic acid which will cause burns. Do not get it in eyes, on skin, or in clothing. In case of contact, flush skin or eyes with water for at least 15 minutes. Get medical attention.

These are the steps you should use in cleaning the processor:

(1) Drain the developer and remove the developer racks.

(2) Install the splash guard to prevent contamination of the fixer if the fixer is to be retained.

(3) Remove the developer system filter cartridge and replace the filter cover.

(4) Fill the two developer tanks with about 10 gallons of premixed cleaner.

(5) Turn on the developer recirculating pump and let the cleaner recirculate for about 15 minutes.

(6) Thoroughly flush the developer racks with warm water. Apply cleaner to the racks with a brush or spray bottle. Rotate the rack while applying cleaner to rollers and side plates.

(7) Flush the racks with warm water and wipe the rollers with a damp sponge to remove cleaner. Make sure the rollers are thoroughly clean.

(8) Clean the number 2 and 3 crossovers as you did the racks.

CAUTION: Use goggles or other eye protection when brushing cleaner.

(9) Drain cleaning solution from the developer tanks and flush them with warm water.

(10) Replace the racks and fill the developer tanks with warm water. Turn on the recirculation pump and the main drive. Run the machine for 5 minutes. Drain the tanks and repeat this procedure until the water is free of discoloration.

(11) Install a new developer filter cartridge and mix new developer solution unless other maintenance is needed at this time.

(12) You can clean the fixing bath system with just warm water in the same way that you cleaned the developer system *except* that you do *not use developer cleaner.*

Exercises (633):

1. Most of your operator maintenance is concerned with what procedure?

2. What should be washed and wiped on a daily basis?

3. Why shouldn't roller racks be cleaned with hot water?

4. Why should you know when periodic maintenance is going to be performed?

5. When is system cleaner used?

6. What protection should you use when scrubbing racks with system cleaner?

7. What should you use to clean out the fixer tanks?

4-2. Perform Operator Maintenance on Photographic Equipment

The extent of operator maintenance may vary from one laboratory to another. Limitations are due in part to the availability of maintenance personnel assigned to the base. If maintenance is readily available, you will probably have very little responsibility or authority for performing major equipment maintenance. However, you should take an interest in keeping your equipment in top condition and bring any problems to the attention of the responsible technician. Mission success depends on properly operating equipment. In this section we will emphasize a few principles of operator maintenance.

634. State principles and identify tools of operator maintenance.

General Principles. Any piece of photographic equipment should be given an operational check prior to its use. Some of the items that fall into this category are camera bodies, shutters, film holders, tripods, flash equipment, rangefinders, viewfinders, timers, processing equipment, lenses, and diaphragms. In the

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course of a single year, a camera and its accessories may be exposed to rain, snow, heat, cold, wind, dust, or extreme dryness. Additionally, laboratory equipment may be exposed to various types of chemical solutions, rust, and corrosion. Often the nature of your assignments prevents you from giving your equipment the protection it needs. Naturally, exposure to the elements takes its toll. Unless they are protected, bellows develop mildew, mechanical parts get rusty, leather dries out, lens elements separate, gear trains wear, and components of processing equipment and machines corrode. Only by careful attention and diligent care can you hold the deterioration of this equipment to a minimum.

It must be emphasized that the most important aspect of operator maintenance is cleanliness. Cleanliness is the basis for all photographic quality control. Disassembly of cameras or machinery is normally undertaken only by photographic repair specialists unless they are unavailable and mission requirements (for instance in a war zone) do not permit other alternatives (such as shipping the equipment to a repair depot).

The importance of good operator maintenance cannot be overemphasized. Operator maintenance must become an integral part of your photographic efforts; in fact, it must become a habit. You must acquire the habit of checking and cleaning each item of equipment before and after using it.

For example, one of your most useful cameras is the Super Speed Graphic. Although it is quite durable, the treatment this camera receives in handling and storage influences the amount of repair and overhaul required to keep it in a serviceable condition. You must treat it as if it were your own. In general, it must be kept dry and free of dust and dirt. When a camera is used or stored in a warm, moist climate, you must clean it more frequently to prevent rust and corrosion. You should check the camera prior to going out on a mission. Inspect the condition and operation of the shutter and the solenoid. Check the focus of the rangefinder, ground glass, and focusing scale against each other. Go over the entire camera, inspecting all the working parts. Check all accessories that you are planning to use as well.

NOTE: Prepare a checklist for all the pieces of equipment you use. Use the checklist prior to use. This will prevent mission failure which reflects badly upon you.

Tools. As we have mentioned, you may need to perform certain minor maintenance jobs on items of photographic gear. To do such maintenance, you need some common tools, and you must use these tools properly. Have you ever seen the result of tool misuse, such as the virtual absence of a slot in a wood screw or rounded off hex heads on machine screws? We hope that as a result of this brief study you will not be guilty of such misuse of tools.

A screwdriver is designed for one specific purpose; that is, to tighten or loosen screws. It is not designed to be used as a crowbar, a bottle opener, or a punch. They are quite often used this way, and for this reason there are many broken tips and bent shanks. Screwdrivers are usually classed as standard, crosspoint (Phillips or Reed and Prince), or offset. These types may have variations to do specific jobs.

The standard screwdriver is suitable for most ordinary jobs. You determine the size of a standard screwdriver by measuring from the tip of the blade to the handle. The blade must have sharp corners and must fit the slot in the screw snugly to prevent slipping and damaging the slot.

The crosspoint screwdriver may be one of two types—Phillips or Reed and Prince. They are specially shaped to fit cross-slotted screws. There is a difference in the blades of these screwdrivers. Because of this difference, these screwdrivers are not to be used interchangeably, as they could damage the screw head.

The offset screwdriver makes it possible for you to work in tight corners where straight types cannot enter. The two blades of this screwdriver are set at right angles to each other so that you can turn the screw a quarter-turn at a time by using opposite ends alternately. The offset screwdriver may be either a standard or a crosspoint.

Ratchet screwdrivers are designed so that once the blade is inserted into the screw slot, you can turn the screw completely in or out by the ratchet action without removing and reinserting the driver blade for each turn of the screw. The ratchet screwdriver may have either a standard or a crosspoint blade, or the blades may be interchangeable. On offset ratchet screwdrivers, one end may be standard and the other crosspoint. The ratchet direction of this screwdriver is controlled by a small lever on the handle of the screwdriver.

As you well know, pliers are very useful tools; they are intended for holding small objects and for bending or cutting thin wire or metal strips. Pliers vary in size—from small pliers used by electronic technicians to large ones used by linemen.

Adjustable combination pliers are often called slip joint pliers. They are used for cutting and twisting wire, for pulling or spreading cotter pins, and for general utility operations. They are very rugged, and the jaws can be opened to more than one size or opening because of the adjustable pivot or slip joint. Adjustable combination pliers are useful for holding round stock or light metal, but you should never use them instead of a wrench.

Longnose (needle) pliers are used for general work where space is limited and parts are small. They are suitable for bending or forming fine wire or thin sheet metal. These pliers may or may not have side cutters behind the gripping surface of the jaws. The cutter portion, if present, is usually fine for cutting light material, such as soft iron, brass, or copper wire.

Diagonal-cutting pliers consist of two cutting edges set at an angle of 15° or 20° with respect to the length of the tool. They are used for cutting wire or electrical component leads. The most common misuse of diagonal cutters is forcing them to cut heavier wire or metal than they were intended for.

Side-cutting pliers are heavy duty pliers that combine the gripping jaws of the combination pliers and the cutting surface of the diagonal cutters. The jaws of the side-cutting pliers are broader than those of the combination pliers. Side-cutters are used for cutting heavy wire. The jaws are excellent for pulling and bending heavy gage electrical conductors. The cutting edges can cut heavy gage soft wire.

A wrench is a tool used to apply a turning force to boltheads, nuts, and capscrews, or to grip round material such as pipes, studs, or round rods. Adjustable wrenches have one fixed jaw and one jaw that is movable by the use of a screw adjustment. The adjustable jaw can be opened or closed to fit the flats of the nut or to fit the bolthead to be turned. As a rule, adjustable wrenches are suitable for heavy duty work in places easy to reach. They have the disadvantage of tending to round off the corners of hex nuts unless jaws are closely adjusted to fit the nut. When you are using the adjustable wrench, place the strain on the fixed jaw and not on the movable jaw. If you put strain on the movable jaw, you may spread the jaws if you apply too great a force.

Use socket wrenches when you must operate in close or inaccessible places. Sockets are used with a ratchet handle which requires only a very short swing. The sockets are supplied in sets to fit standard size nuts and are easily fitted onto, or removed from, the handle. Sockets usually come with 6- or 12-point surfaces inside the head. You can tighten the nut completely without removing the wrench from the nut. Socket wrenches may be used with a variety of drives, such as (a) speed handle, (b) extension, (c) ratchet handle, (d) T-handle, and (e) hinged handle, or breaker bar.

Open-end wrenches are nonadjustable. They may be open on either or both ends of the wrench. They are light, strong, and convenient for working in a limited space. The jaws are set at an angle (usually 15°), and it is easy to increase the swing of the wrench by turning it over. Open-end wrenches normally range in size from 3/16 to 1 1/4 inches and are usually graduated in 1/16-inch increments. Wrenches for special uses may be obtained in 1/32- or 1/64-inch graduations. On wrenches with both ends open, one end is the next size larger than the other end. The wrenches are proportional in length to the size of the openings. This proportions the leverage of the wrench to the nut and helps prevent damage to the wrench and to the work.

Box wrenches are also solid, nonadjustable wrenches. They range in the same sizes as open end wrenches. Unlike open-end wrenches, which have flat jaws, box wrenches have 6-, 8-, 12-, or 16-point surfaces inside the head-like socket wrenches. The number of points determines the strength of the wrench. The most common box wrench is the 12 point, which gives a maximum swing of 30°. A box end wrench completely encloses or "boxes" the nut. The sides of the wrench are thin so that the wrench can be used on nuts close to another object. This wrench can be used in places where another type would never fit.

The hex or Allen wrench is an L-shaped device designed to fit setscrews or hexagonal socket heads of screws and bolts. The wrenches usually come in sets containing sizes from 1/32 to 3/8 inch.

NOTE: Not only is it important to use the right tool for the job, but all your tools must be properly maintained so that they will be available for your use.

Exercises (634):

1. What is the most important aspect of operator maintenance?

2. Why is it important to check all your equipment prior to going out on a mission?

3. Identify a tool listed in Column A with its function listed in Column B.

Column A	*Column B*
1. Offset screwdriver	a. Screwdriver for cross-slotted screws
2. Reed screwdriver	b. Plier designed for forming fine wire
3. Longnose pliers	c. Wrench designed for hexagonal socket heads
4 Standard screwdriver	d. Screwdriver designed for working in tight corners
5. Side-cutting pliers	e. Plier designed for cutting heavy gage electrical wire
6. Allen wrench	f. Most ordinary jobs to tighten or loosen screws.

Color Photography

COLOR ADDS a realistic dimension to photographic work. At one time color was a difficult medium to work with, requiring specialized cameras and processing only by the film's manufacturer. Now color materials have been greatly improved to a point that color is far more popular than black and white. Air Force wide, color photography is important for slide briefings, documentation, scientific studies, reconnaissance and displays. In this chapter we will discuss the basic principles of color photography, including how to expose, process, and print color.

5-1. Principles of Color Photography

The basics of color photography require that you understand the nature of light, and the additive and subtractive processes which are the two systems that can produce color. Each of these subjects will be discussed in this section.

635. Identify basic principles of color photography.

Light. Without light, color does not exist. Light is defined as that portion of the electromagnetic spectrum that affects the sensory organs of the eye and produces the sensation of vision. The visible portion of the spectrum is the part primarily responsible for photographic exposure, but infrared (IR) and ultraviolet (UV) also play a significant part in the field of photography. Infrared, ultraviolet, and visible light make up what is known as the optical spectrum. Because infrared and ultraviolet radiations obey the laws of optics, they have special applications in the area of photographic research. They are also used extensively in investigative and medical research photography.

The visible light portion of the electromagnetic spectrum (see fig. 5-1) extends approximately 400 to 700 nanometers in range. (A nanometer is a metric measurement equal to 1 billionth of a meter.) The radiations at the 400 nm end of the spectrum appear blue to the eye; those radiations around 500 nm appear predominantly green; and those in the 700 nm region of the spectrum appear red. Infrared and ultraviolet radiations fall into the spectrum immediately above and below the range of visible radiations. Infrared falls immediately above the 700 nm portion of the spectrum and ultraviolet immediately below the 400 nm portion.

"White light" is a term used to identify the visible spectrum when all of the wavelengths, from 400 nm to 700 nm, are present in nearly equal amounts. However, due to the adaptability of the eye and various human and psychological reasons, it is impossible to establish a standard for white light. For example, indoor lighting and sunlight both appear to be white.

Why do they both appear white when it is a known fact that they do not contain the same amounts of visible radiation?

They both appear white because the receptors in the eye, which are sensitive to red, green, and blue wavelengths of light, are capable of adapting their sensitivity to compensate for imbalances in wavelength proportions. For example, sunlight has a higher percentage of blue and green wavelengths and is relatively deficient in the red region of the spectrum. As a result, the red receptor increases in sensitivity until there is the necessary balance of wavelength impulses reaching the brain and the viewer perceives the sensation of white light.

While the individual receptors have the capability of adjusting in sensitivity, the eye itself is not selective in regard to individual wavelengths. In order for the eye to see a single wavelength, it must be isolated and presented alone. For example, the eye cannot be selectively turned to red, green, or blue radiations when they are presented in combination.

It should be noted, however, that it is possible for the eye to visualize colors not present in the spectrum. If equal amounts of red and blue wavelengths strike the eye, we see a purplish or magenta color. Because red and blue are at opposite ends, magenta does not exist in the visible spectrum. Actually, we see magenta because the surface is reflecting equal amounts of incident red and blue radiations and absorbing the green. Yellow is another example of this phenomena. Yellow occupies only a small part of the visible spectrum, approximately 575 to 590 nanometers. If only yellow radiations were reflected to the eye, the reflecting surface would be so dark as to appear black.

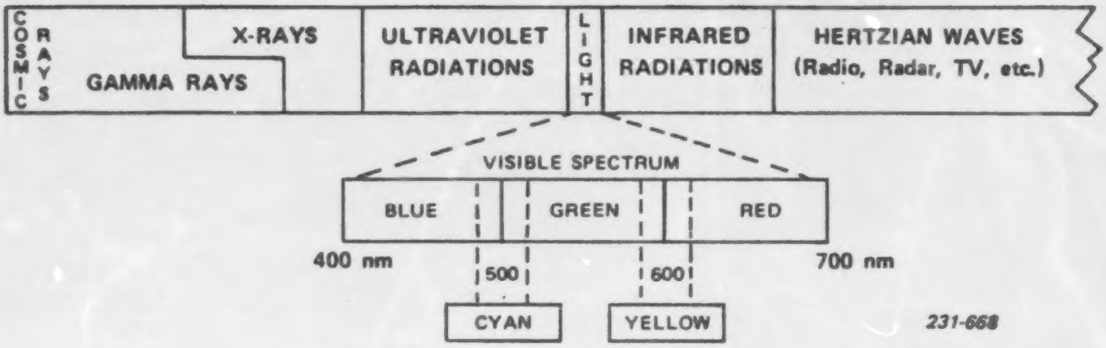

Figure 5-1. Electromagnetic spectrum.

Most yellow, seen by the eye, is the result of the surface absorbing incident blue radiations and reflecting the red and green.

Evaluation of Color. To evaluate color quality effectively, we need to know more about how color is produced. Some of the more important methods of color production are absorption, selective reflection, scattering, interference, dispersion, and fluorescence.

Most color occurs when illumination, falling on the subject, is not evenly absorbed at all wavelengths. If the subject did absorb all wavelengths equally, we would have to illuminate the subject with colored light in order to see color. Thus, under normal conditions, the color of the subject is dependent on its absorption and reflection characteristics in relation to the various wavelengths present in the illumination.

Selective reflection is a characteristic displayed by certain metals. Gold, copper, and brass are some of the metals that exhibit these qualities. Specular reflections from other metals tend to be white. The selective reflection of red and yellow light, by the front surface of gold metal, gives it its characteristic color.

Variations in atmospheric density, airborne particles, such as dust, droplets of water, and ice crystals, have the ability to affect the shorter wavelengths in the spectrum to a greater degree. When light enters the atmosphere, the shorter wavelengths of light are scattered more than longer wavelengths. This alters the color quality of the incident light. Haze is the result of light scattered by the atmosphere.

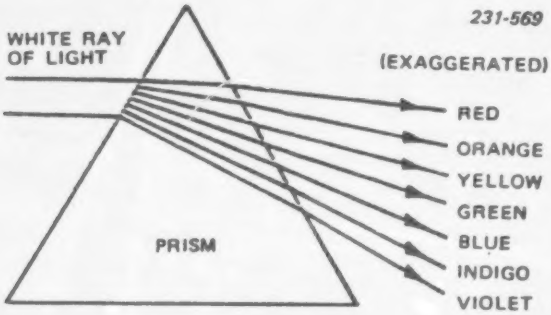

Figure 5-2. Dispersion.

Have you ever noticed the patterns of color produced by oil on the surface of water and wondered what caused them? They are produced by lightwave interference from two surfaces spaced a few millimicrons apart. When light is reflected from these two surfaces, a portion of the reflected light will be cancelled when the two light waves meet—one reflected from each surface. This interference produces the color you see.

The color patterns, formed by light-wave interference, are known as Newton's rings. Under certain circumstances, Newton rings can present problems when working with color materials. They may occur if you are printing color using a glass negative carrier. The irregular contact between the glass and the negative surface may produce interference effects. This effect may also occur in glass-mounted slides. The use of a glassless carrier and a special glass for the slide mounts can remedy these problems.

The rainbow is a natural example of dispersion. For a given medium, as the wavelength of light increases, the angle of refraction decreases. Light waves, striking the droplets of water in the atmosphere, are refracted according to wavelength into the colors of the spectrum. Dispersion of these wavelengths creates one of nature's more colorful spectacles—the rainbow. A prism may also be used to disperse light. (See fig. 5-2.)

Color can also be produced through fluorescence. Fluorescence is the ability of a material to absorb radiations of one wavelength and reradiate them at another, usually longer, wavelength. This is what takes place in the fluorescent lamp. The fluorescent lamp is really a mercury vapor lamp that has been coated with a powder that fluoresces when bombarded with ultraviolet radiation. When power is applied to the lamp, the mercury emits ultraviolet radiations which are absorbed by the fluorescent power and reradiated as visible light.

When we assign a color to anything, we are attempting to describe certain characteristics of the object under normal conditions. We must remember that these characteristics will vary with changes in spectral quality and intensity of illumination. Since it is impossible to specify color under all conditions of illumination, most color is identified when viewed under normal daylight or tungsten conditions.

Three terms used to help identify color are hue, brightness, and saturation. They are used as tools to assist in color communications. If we are to be more explicit in color communication, we should know something about these terms.

Hue is a term used to assign a general color to the subject. If we say the subject is red or yellow, we are identifying the hue. However, there are as many shades as wavelengths in that portion of the spectrum. If we assign a hue only, we are less than specific in color identification.

To further describe a color, we might say that it is light green or dark red. This is an attempt to describe the brightness of the color and is some measure of its absorption and reflection characteristics.

Saturation is used to describe the purity of a color. If the color is pure, it could be called a brilliant color, as a brilliant red. Impure colors appear dull. Saturation is determined by comparing the color to a neutral gray of the same brightness.

Why Colors Can Be Photographed. Regardless of the process you use to obtain your color product, the starting point is the same as that developed by James Clark Maxwell. He demonstrated that a subject could be photographed and reproduced in its natural colors. Maxwell illustrated his color process by placing in separate projectors three positive transparencies of a still-life subject he photographed. He inserted a primary color filter in the light path of each projector, and the red, green, and blue images superimposed on a screen. Maxwell's projected color image was not particularly good, but the experiment did soundly demonstrate an important color principle.

Maxwell's demonstration, made to a group of scientists in 1861, was the forerunner of all present color processes. He made the original exposure by using liquid filters to transmit the three basic colors of light. A negative was made through each of his red, green, and blue filters. This set of three negatives (which were black and white) represented in silver density the ratio of red, green, and blue in the original subject. Each of the negatives he then printed on film to give a positive transparency.

He projected the three positives through the same primary colored filters used in making the original negatives. When he projected all three positives on the same screen and in register, one on top of the other, the result was a color reproduction of the original subject matter. This process is graphically shown in figure 5-3, where you see how the three color negatives

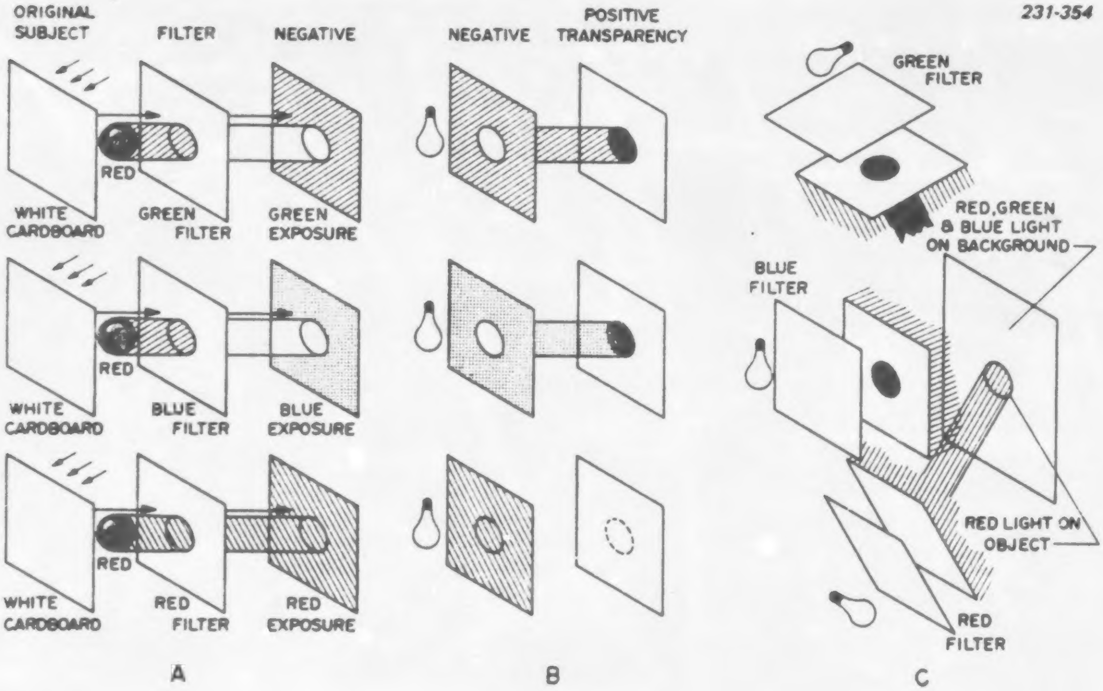

Figure 5-3. Maxwell's principle.

of a red ball are made through the three filters (part A). Follow the green-filter projection and notice that the resulting silver density represents the quantity of green reflected from the red ball. The quantity is, of course, zero; therefore, a background exposure is made, but no exposure is made for the ball.

When the negative is reversed to a positive (part B of fig. 5-3), the background becomes clear and the ball is black. If this positive is projected through a green filter, it is obvious that no green light will project to the screen in the position occupied by the ball. Since the ball is not green, this is entirely correct. With just the green filter positive, the projection is a green background with a black ball. Using all three positives (part C of fig. 5-3), the background projects white, which is the sum of all three primary colors. The ball image projects red, because only red light is allowed to fall on the area of the screen.

One outstanding deficiency is immediately apparent when considering Maxwell's demonstration, and that is its lack of permanence. A color picture could be projected on a screen, but that was all. This was not a photograph that could be mounted in a picture frame or placed in an album. Commercial use of Maxwell's discoveries had to wait for a manufacturing process that could use their possibilities.

Exercise (635):

1. State basic principles of color photography by completing the following statements.
   a. Without _________ color does not exist.

   b. The optical spectrum is made up of _________ light, plus _________ and _________ .

   c. Visible light runs from _________ to _____ nanometers.

   d. Due to eye _________ both indoor and daylight illumination may appear white.

   e. Equal amounts of blue and red light produce _______ .

   f. The color of an object is determined by its _________ and _________ characteristics.

   g. Selective reflection is a characteristic displayed by _________ .

   h. Newton rings are caused by _____ _____ __________ .

   i. The rainbow is caused by _________ .

   j. _________ material absorbs radiation at one wavelength and re-radiates it at another.

   k. Impure color lacks _________ .

   l. Maxwell's demonstration used the three _____ colors.

636. Complete statements on the additive principle of color photography.

The Additive Color Process. Exposure of color film, and to a more limited degree color printing paper, applies the principles of the additive color process. The additive process, applying the principles developed by Maxwell, uses the primary colors of blue, green, and red.

When equal parts of blue, green, and red light are projected from separate projectors and are partially superimposed on a screen, you see in the area of overlap of all three colors, white, as shown in figure 5-4. The area of overlap between the blue and green light produces cyan (blue green), the area of overlap of the red and blue light produces magenta, and the overlap of the red and green light produces yellow. Almost any desired color match can be produced by varying the amount of one of the two colors used for producing that color. For example, if you have equal proportions of red and green, the result is yellow; by increasing the amount of red, the result is orange. Since matching a wide range of colors with red, green, and blue light involves addition of the colored light, the primary colors are often identified further as the additive primaries

In color photography, the three colors produced by mixtures of additive primaries in pairs are of particular importance. These colors—cyan, magenta, and yellow—are known as the subtractive primaries. Since each represents white light minus one of the additive primaries, the subtractive primaries are the complements of the additive primaries. For example, cyan and red light blend together to give white light. Similarly, magenta is complementary to green, and yellow is complementary to blue.

At this point, refer to figure 5-5 and study the illustration of the color star. Remember which colors are the additive primaries (blue, green, and red), and notice that the subtractive primary colors between any two of the additive primaries are mixtures of these two primary colors. Also, notice the colors that are directly opposite to each other in this star; these colors are complementary to each other.

Although the original photographic record on color film uses the additive primary colors, these are not suitable for the final color product. This is because any combination of primary colors over one light source results in neutral density. A transparency, for example, must be viewable when you use only one white light source. It is the subtractive process, discussed in the next objective, that makes the "final product" possible.

Exercise (636):

1. Complete the following statements regarding the additive process.
   a. The additive color process requires ________ separate light sources.

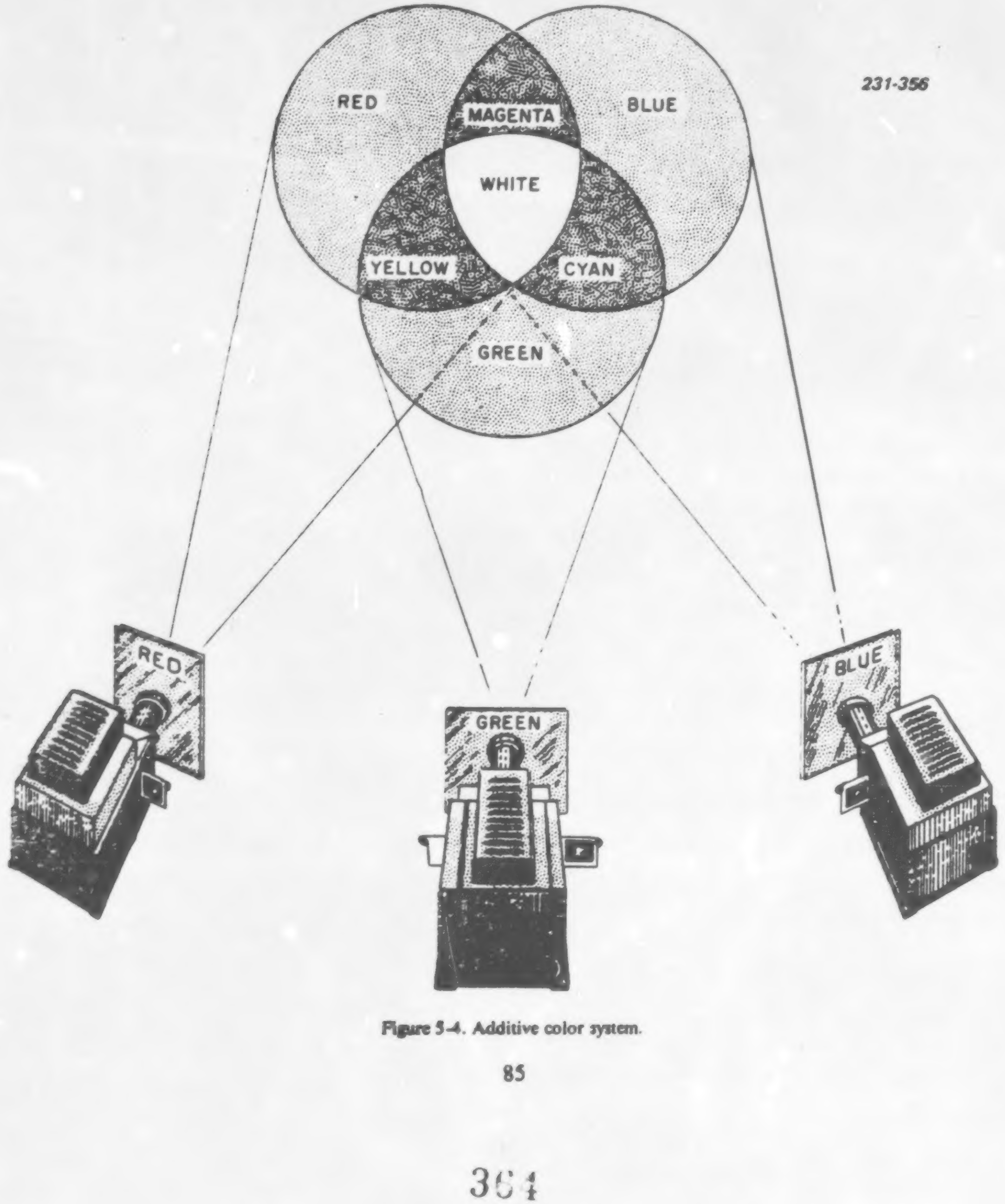

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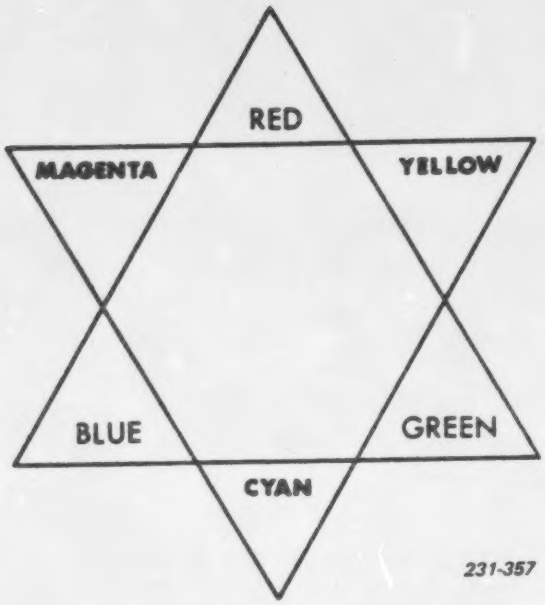
Figure 5-4. Additive color system.



RED + GREEN = YELLOW
RED + BLUE = MAGENTA
BLUE + GREEN = CYAN

Figure 5-5. Color star.

b. A combination of equal amounts of red and green light produces ________ light.

c. The subtractive primaries are __________, ________, and ________.

d. Yellow is the complement of ________ light.

637. Complete statements on the subtractive principle of color photography.

The Subtractive Color Process. In the additive color process where three projectors were used (one lens was covered with a red filter, one with a green filter, and one with a blue filter), we were able to produce any desired color. Theoretically, any filter transmits light of its own color and absorbs all other colors. The amount of absorption depends upon the density of the filter. Therefore, we could not place all three filters over a single light source. To a certain extent, the filters are mutually exclusive; that is, none of them transmits light passed by either one of the other two. Consequently, any two of the filters used in combination in front of a single light source absorb all of the light.

Since a filter of any of the additive primary colors transmits only that one primary color, the subtractive primary colors are used as filters in the structure of color materials. This makes it possible to transmit any two of the additive primary colors and subtract the third.

NOTE: The term subtractive primary color has the same meaning as secondary color which was used when we discussed filters. The colors yellow, cyan, and magenta can be called either secondary colors or subtractive primaries.

A cyan filter transmits blue and green light, but absorbs red light; hence, it subtracts red from white light. Similarly, a magenta filter (which transmits red and blue) functions by subtracting green from white light.

Since each of the subtractive primary filters transmits approximately two-thirds of the visible spectrum, we can superimpose any two of them over a single light source to produce other colors. Refer to figure 5-6 for an illustration of the principle of the subtractive color process. Notice that the combination of any pair of the subtractive primary colors in equal densities produces one of the additive primary colors. For example, a yellow filter transmits red and green and absorbs blue, and a magenta filter transmits red and blue and subtracts green from the light source. When these two filters are used over a single light source, the one color that is transmitted by both magenta and yellow is red. Therefore, yellow plus magenta produces red. In the same manner, when yellow and cyan are used in combination, the one

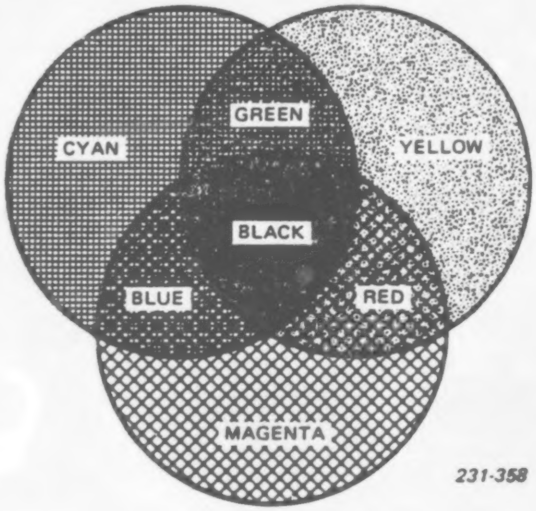


Figure 5-6. Subtractive color system.

color that is transmitted by both filters is green; since yellow transmits red and green, and cyan transmits blue and green. Cyan plus magenta produces blue, because blue is transmitted by both filters. Where all three filters overlap in the center, all of the light is absorbed, and the result is black.

By varying the density of either one of the filters, any desired change in the color produced can be brought about. For example, to change the appearance of red to make it an orange red, increase the amount of yellow; in other words, decrease the amount of magenta.

Exercise (637):

1. Complete the following statements on the subtractive principles.
   a. A primary filter transmits __________ color of light and absorbs __________ .
   b. A combination of cyan and magenta filters will pass __________ light.
   c. A cyan filter passes __________ and ______ light.
   d. Three secondary filters over one light source would pass __________ light.
   e. Red can be produced by passing light through a combination of __________ and __________ filters.

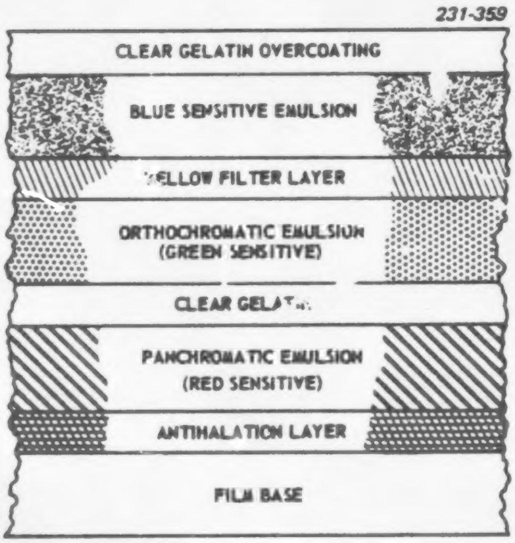


Figure 5-7. Cross section of color film.

5-2. Color Film Characteristics

Color films fall into two basic types: reversal and negative. Reversal color films, identified by the suffix "chrome" (Kodachrome, Ektachrome, Agfachrome, etc.), are processed to a positive transparency (slide). The image can then be projected on a screen or viewed on a light box. Negative films, identified by the suffix "color" (Ektacolor, Agfacolor, Fujicolor, etc.), are processed to a negative which then is printed to produce prints. Within each category of film you can obtain different emulsion sizes (35mm, 120, 4x5, 8x10, etc.) and films balanced for different types of light sources (daylight, tungsten, photofloods, etc.). Which you choose depends on your mission requirements. In this section we briefly discuss the characteristics of color films.

638. Complete statements on the characteristics of color film.

Structure of Color Film. Today, color materials consist of three thin coats of emulsion on a single film base. Each emulsion is separated from the next by an extremely thin interlayer of gelatin. Such a structure is known as multilayer film.

Figure 5-7 shows a cross section of a typical color film. (The difference between reversal and negative films will become apparent when we discuss processing of color film.) Start at the top and work down the diagram. An antiabrasion coating protects the film from minor abrasions. The next layer is a blue-sensitive emulsion layer. The next layer is a built-in yellow filter made of collodial silver. The purpose of the filter is to absorb any excess blue that was not recorded in the top emulsion layer. This prevents any recording of blue in the middle emulsion layer. The middle emulsion layer is orthochromatic (sensitive to green and blue) and its purpose is to record the green light. The bottom emulsion layer is panchromatic with a low sensitivity to green. Since blue and green have been recorded in the first two layers, the bottom layer is to record red.

In effect then, a sheet of color film is made up of three separate emulsion layers, each layer is designed to record only one of the additive primary colors of light. Secondary colors, such as yellow, are recorded in the two layers which form to make up the color (ex. green and red for yellow). White light is recorded in all three levels.

Color Balance and the Quality of Illumination. The two major divisions of color films are based upon the quality of the light to which the film is to be

TABLE 5-1
APPROXIMATE COLOR TEMPERATURE OF COMMONLY USED LIGHT SOURCES

231-696

LIGHT SOURCE	DEGREES KELVIN
Tungsten House Lamps	2870 - 2810
Lamps for Color Photography	3200
Photoflood Lamps	3400
White Fluorescent Lamps	3500
Clear Flashlamps	3800
Photoflash "22B" or "5B"	5400
Daylight (Standard)	5400
Average 10 A.M. to 3 P.M. Sunlight	6000 - 6200
Daylight Fluorescent Lamps	6500
Electronic Flashtubes	5800 - 7000
Overcast Sky	6800
Clear Blue Sky	12,000 and up

exposed—daylight or tungsten. To distinguish between daylight and various artificial light sources, we commonly refer to their differences in terms of color temperature. Remember, however, that color temperature refers to the color of light as seen by a human observer with normal eyesight. There is often a great difference between the effect of color as we see it and its actual photographic effect.

A person becomes accustomed to the artificial illumination in a room, and the light appears to be white. The same room illuminated with daylight likewise seems to be illuminated with white light. However, if you turn on a tungsten lamp in a room that is illuminated by daylight, the tungsten light appears to have a yellowish cast. That which appears to be white may not be white, since the human eye is a poor measuring tool to determine the color quality of light. Thus, we need some method of measuring the color of what appears to be white light. One such method of measurement is the color temperature scale, expressed as degrees Kelvin—the temperature to which a black body radiator must be heated in order to emit light equal to a source such as tungsten lamps, the sun, etc. The scale starts at −273° centrigrade (absolute zero), which is designated as zero Kelvin. The scale has become universal in the measurement of color temperature.

All tungsten or daylight sources are not at the same color temperature. Table 5-1 lists the commonly used light sources and their approximate color temperatures.

From your experience with the film characteristics of black-and-white film, you probably recall that the effective film speed often changed when you switched from daylight to tungsten light. The reason for this change was the difference in the spectral quality of the color content of the light. A change in film speed in black-and-white film usually compensates for a radical change in light quality, but this is not the case with color film; here you must consider color temperature. Color film is in correct balance for only one type of light and should be used under specific light conditions. If these conditions change, then the colors you photograph appear degraded or out of balance. Normally, each manufacturer makes at least two types of color film—one to be used under tungsten light and the other to be used under daylight conditions.

A knowledge of color temperature is valuable to you; however, the Kelvin rating of a light source is not the only factor to consider. For example, two light sources, a tungsten and a fluorescent, may be rated as having the same color temperature, but their effect upon color film may vary considerably because of differences in their spectral distribution qualities. For the same basic reason, the selection of a filter for proper balance cannot always be predicted on the basis of its effect upon color temperature alone, as you will discover by following the manufacturer's recommendations and by making tests of your own.

Daylight Film. Daylight color film is balanced at 5400 K. This means that because of the high blue content of a light with this color temperature, the film is made with a relatively lower sensitivity in the blue record emulsion and with a higher sensitivity in the red record emulsion. Consequently, the excessive blue is minimized, and all reds are strengthened in the final transparency. As a consequence the film must be exposed to predominantly blue light sources like daylight or electronic flash.

When daylight film is exposed to light with a preponderance of red, like tungsten lighting, this excess red degrades all colors, and the transparency takes on a reddish cast. Essentially the same effect is obtained by exposing daylight film just after sunrise or just before sunset. You have probably noticed the predominantly red light at these times even though the eye is a poor judge of color. The opposite, or a bluish cast, commonly appears in various winter snow scenes. As a matter of fact, the shadows are definitely blue in any outdoor picture, because they are illuminated by sky rather than by sunlight. Skylight is largely blue because the short wavelengths of blue light are easily scattered by atmospheric dust and haze. This, then, is the light that illuminates shadow areas.

Off-color transparencies and prints are not necessarily poor. Take a look at the color illustrations in any photographic magazine. Many top photographers deliberately use light of the wrong color temperature to shoot pictures. A reddish cast produces a warm tone, while an excess of blue is cold.

Of course, these are special effects designed to create a particular mood.

Tungsten Film. As might be expected, film manufacturers also produce color materials that are designed for use under tungsten illumination. These emulsions are specifically color balanced for illumination that measures either 3200 K (tungsten) or 3400 K (photofloods). Tungsten lighting is rich in red; therefore, the tungsten type of color films are made with a pronounced sensitivity to blue in order to compensate for the lack of abundance of blue under this kind of illumination. This is the reason why, when you examine a roll of tungsten transparency film exposed in daylight, the colors appear to have an overall bluish cast. By using the appropriate conversion filter, you can use tungsten film in daylight and get satisfactory results.

It is important to determine the exact tungsten rating of the illumination so that you can choose the appropriate tungsten film and any accessory filters that may be necessary. You also should know that the color temperature of a lighting source can change with time and with line voltage fluctuations. For example, many tungsten bulbs designed for photographic use are only guaranteed to put out a particular temperature for a couple of hours. In addition, a line voltage change of 1 volt will change the color temperature by 10 K in the direction of the change. Therefore a 10-volt increase would increase the color temperature by 100.

NOTE: While not covered in this CDC, there are color temperature meters for measuring the color temperature of any light source. This type of meter is invaluable in color photography.

Exercise (638):

1. Complete statements on the characteristics of color film.
   a. Color films have _____ emulsion layers.

   b. The middle emulsion in color film is designed to record _____ light.

   c. A _____ collodial silver layer is found between the _____ and _____ emulsion layers of color film.

   d. The bottom emulsion layer of color film is a _________ type film that is designed to record _______ light.

   e. Cyan would be recorded in the _______ and _______ emulsion layers.

   f. Tungsten house lamps would be richer in _______ light than tungsten lamps designed for color photography.

   g. Daylight is rich in _____ light.

   h. Daylight color film exposed under tungsten light would give the images a heavy _____ cast.

   i. Tungsten film is designed for light sources that are rich in _____ light.

   j. If the line voltage on a 3200 K lamp went up 20 volts, the Kelvin temperature would change to _____ .

639. State the principles of the care and storage of color film.

Care of Color Materials. Much of our discussion about the care, storage, and handling of black-and-white materials applies equally well to color materials. As you probably know from your experience in buying color film, the cost of color materials and processing is almost three times the cost of using black-and-white films. You can therefore appreciate that the Air Force has a substantial overall investment in color materials.

It is extremely important that any changes in either the length, width, or thickness of color materials be avoided because of their multilayer structure. As a rule, by maintaining control over the relative humidity (RH) content and temperature of a properly constructed film storage area, you can protect color materials from environments that cause these changes. As is the case with black-and-white films, keep the relative humidity of the storage facility at 40 to 50 percent. This is particularly important with materials which have been exposed or processed, for dye changes will result because of high humidity.

Color materials require low temperatures, as well as controlled humidity conditions, in order to preserve the initial film speed and to maintain color balance. To assure high quality, sealed containers of most kinds

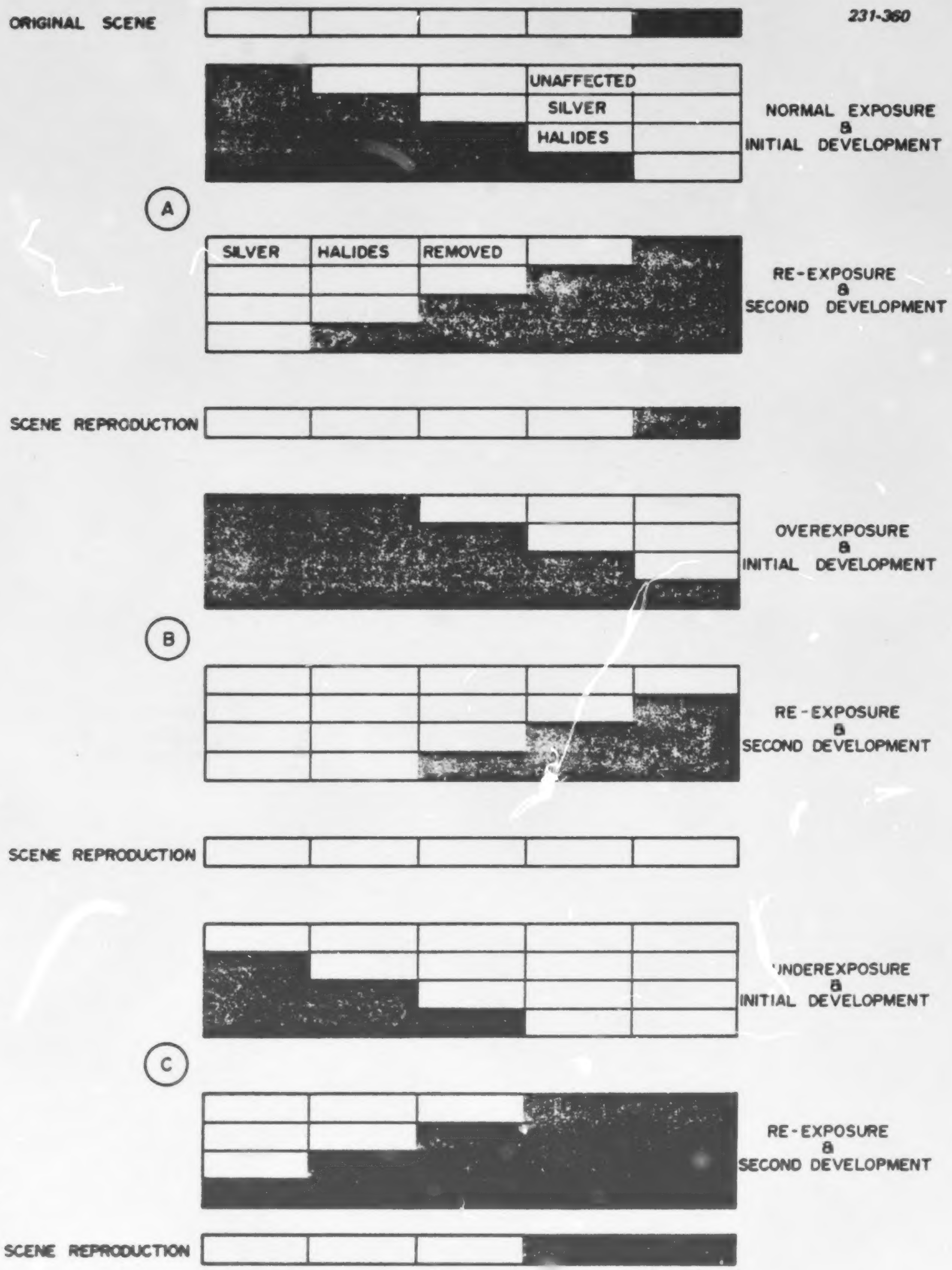

ORIGINAL SCENE
231-360
UNAFFECTED
SILVER
HALIDES
NORMAL EXPOSURE & INITIAL DEVELOPMENT
A
SILVER HALIDES REMOVED
RE-EXPOSURE & SECOND DEVELOPMENT
SCENE REPRODUCTION
OVEREXPOSURE & INITIAL DEVELOPMENT
B
RE-EXPOSURE & SECOND DEVELOPMENT
SCENE REPRODUCTION
UNDEREXPOSURE & INITIAL DEVELOPMENT
C
RE-EXPOSURE & SECOND DEVELOPMENT
SCENE REPRODUCTION

Figure 5-8. Exposure latitude of reversal film.

of color film can be stored safely for a period of several months at a temperature of 55°F or less. For periods longer than 6 months, it is customary to store color materials at 0° to −10°F.

NOTE: For good results it is necessary to allow the material to warm up to working temperatures prior to use.

In addition to heat and humidity, color materials should be guarded against contamination of all kinds. Film and other materials should never be stored near chemicals or any other source of vapors. Such vapors can have permanent effect on the color quality of your materials.

Exercises (639):

1. Color film should be stored in an environment which has what range of relative humidity?

2. What should be the temperature for long-term storage of color film?

3. What is likely to happen to film that is not properly stored?

4. Should color film be stored near photo chemicals? Why?

5-3. Expose Color Film

In contrast with the problems inherent in earlier color processes, present-day color films are highly standardized and effective. Even so, you must control your product if you are to obtain consistently good results under varying conditions. In this section we will cover a few points that you should remember in exposing color films.

640. State the principles and techniques of exposing reversal color film.

Exposing Reversal Color Film. Unlike panchromatic black-and-white films, color emulsions can accurately reproduce a much narrower range of brightness values. Normally a scene's contrast cannot be greater than 3:1 to hold both the shadows and highlights. This calls upon the photographer to use supplementary lighting for both indoor and outdoor work to keep contrast low. This particularly is true with reversal films. The reversal process basically uses up all of the sensitive silver halides in order to obtain the necessary final positive image. There is little room for error and exposures must normally be within one-half F stop of perfect in order to guarantee top quality results.

NOTE: Prove this to yourself by picking a typical outdoor scene and shooting an exposure test with the color reversal film that you are using. Bracket your exposures from three under through three over in half-stop increments. Such a test will give you a good idea of the latitude of the film you are using.

Figure 5-8 illustrates, in a general way, the influence that narrow film latitude has on the reproduction of a scene when you are using reversal film. For purposes of simplicity, consider each pair of the three views by its respective letter as cross sections of color film. In each case, the upper cross section represents the results of the film's initial exposure and its first development. Imagine that the original subject was illuminated by a predominantly red light such as you would find in a vivid sunset. Consider the shadows, halftones, as well as highlights, as different densities of the same color. Normally, color material can record more shades of brightness values than figure 5-8 shows. The lower cross section represents the film after it has been reexposed and run through the color developer. In each view, the exposed silver halides are shown in black, whereas portions of the emulsions that remain blank are not affected by light.

With a normal exposure, about one-half of the silver halides are affected (see A of fig. 5-8). Note that the film reproduction of the subject would record the same range of brightness values as the original scene. Compare the scene results of the normal exposure with those of overexposure and underexposure. The former, shown in B, would appear as a very thin transparency, since the initial overexposure has affected the major portion of the silver halides. A considerably smaller amount of halides remains to be affected by reexposure and color development. The highlights appear washed out, as little dye is produced. Underexposure, as shown in C, affects less than one-half of the silver halides in the color emulsion. Therefore, when the reversal process forms the positive image, the greater part of the silver halides is affected by reexposure and color development. This results in a much denser positive image which is more satisfactory than an overexposed image.

NOTE: Your understanding of this will increase when we cover processing of reversal film. For now just try to get the idea that as you increase exposure over normal the final transparency will be lacking in color. Conversely, as you decrease exposure, the transparency will become darker and darker.

Exercises (640):

1. What is the exposure latitude of reversal color film?

2. A scene's contrast should not exceed what ratio when using reversal film?

3. What is one way you can reduce a scene's contrast?

4. Heavy dye densities result from what type of reversal exposures?

641. Identify as true or false statements concerning principles and techniques used in exposing negative color film.

Expose Negative Materials. So far we have illustrated color exposure problems in terms of color reversal film. Let us now turn our attention to negative color film.

Negative color film has a few advantages over reversal film. The advantages are these:

- Negative color film has a latitude approaching that of black-and-white film.
- The lighting ratio can be 4:1.
- Color and black-and-white prints can be made from the color negatives. Because the film must be printed, it allows you an opportunity to dodge and burn-in to correct for contrast problems encountered when the film was exposed.

Basic professional negative color sheet or roll film from Kodak comes in two forms: Vericolor II Type S and Vericolor II Type L. It is important that you understand the differences between these two films.

Type S Vericolor II. This film is designed for short exposures. It is specifically for making color negatives at exposure times of 1/10th of a second or shorter. It is balanced for use with electronic flash, blue flash, or daylight without a filter. With the appropriate filter, the film can be exposed with clear flash lamps. It has an ASA of 100.

Type L Vericolor II. This film is designed for long exposures. With it, you can make color negatives at exposure times ranging from 1/50th of a second to 60 seconds. It is balanced for use with 3200 K lamps without filters and can be exposed under photo floods or daylight illumination by using the appropriate filter. It has an ASA of 50 for an exposure of 5 seconds. (You should consult the data sheet that comes with the film for the basic ASA rating for other exposures.)

NOTE: Reciprocity failure is a serious problem in any aspect of color photography. Extremely long or short exposures are likely to cause color shifts with either reversal or negative films. It is therefore important to follow the manufacturer's exposure recommendations for the film you are using.

Negative Quality. The most important single characteristic of a color negative is that it have adequate shadow detail. The exposure latitude of the film depends upon subject color, contrast, and the lighting ratios you use. Exposure latitude ranges from approximately one stop under to two stops over. If there is any doubt concerning the correct exposure, overexpose rather than underexpose. An overexposed negative tends to print warm, or yellowish, but the results are not too objectionable. If the color negative is underexposed, the color balance will be off. If you try to correct for the shadow areas as you print, the highlights tend to go too warm, or reddish; if you try to correct for the highlights, the shadows tend to go too cool, or bluish.

The color balance of a color negative cannot be easily determined visually, but the adequacy of exposure can be. If there is no visible shadow detail, and the shadow areas are clear orange, the negative is underexposed. When the highlights are blocked up, the negative has been overexposed. Evaluation of color negatives may seem very difficult when you first work with them, because of the orange masking. (This orange masking will be understood when you study the processing of color negative film.) You can overcome this by viewing the negatives through a Wratten N-61 green filter. This filter neutralizes the orange masking and makes it possible to view the shadow and highlight areas for detail.

As an aid in determining the color balance of color negatives, a neutral gray card of 18 percent reflectance should be photographed with the subject. Place the card along the edge of the scene where it does not interfere with the subject; however, it must receive the same lighting as the subject. (If this is not possible then shoot one with and without a gray card.) Once this negative has been processed the gray card can be used as a reference in printing.

Exercise (641):

1. Identify each of the following statements regarding the exposure of color negative film as true or false by underlining True or False following the statement.
   a. Color negative film has greater latitude than reversal film. True or False

   b. Type L negative film is designed for daylight use. True or False

   c. Type S film is designed for exposures of a minute or less. True or False

d. Type L film has the same ASA rating throughout its exposure range. True or False

e. To judge a color negative you may have to use an N-61 filter. True or False

f. Unlike reversal film, if you have any doubts about your exposure with negative film, you should tend toward underexposure. True or False

g. To help in printing, you should have a gray card in the scene you are shooting. True or False

5-4. Filters for Color Photography

Color film, unlike the eye, is designed to record light of a specific Kelvin temperature: 5400 K, 3400 K, or 3200 K. Filters are therefore necessary to filter the available light to match the film. There are four categories of filters that perform this task: (1) conversion filters, (2) light-balancing (correction) filters, (3) color compensating filters, and (4) special purpose filters. Filters for color photography are paler than those used for black-and-white photography, but their principles of application are the same.

642. Choose the correct filter to be used under different photographic situations involving color film.

Conversion Filters. Conversion filters are very strong filters and are used for exposing tungsten-type color films under daylight conditions and daylight film under tungsten illumination. The following list will indicate the filter to use:

Film Type	*Lighting*	*Filter*	*F/Stop Increase*
Daylight	3200 K Lamps	80A	2
Daylight	3400 K Lamps (Photofloods)	80B	1 2/3
Daylight	Clear Flash (3800 K)	80C	1
Type A (Balanced for 3400 K)	Daylight	85	2/3
Type B (Balanced for 3200 K)	Daylight	85B	2/3

NOTE: Type 80 filters are blue in color, whereas 85's are yellowish. This and other lists in this section are just guides. You must follow the recommendations of the film's manufacturer.

Light Balancing Filters. Light balancing filters are paler than conversion filters. They are used for slight adjustments within the general light balance of the film (i.e., matching type A film to different types of tungsten lighting, etc.). The following is a list of commonly used light balancing filters:

Film Type	*Filter*	*Purpose*	*F/Stop Increase*
Daylight	81A	Absorbs excess blue in cloudy weather, shade or when using electronic flash indoors.	1/3
Type B	81A	When using type B film with photofloods.	1/3
Daylight	81B	Same application as an 81A but with stronger results.	1/3
Type A	81C	For using clear flash bulbs with type A film.	1/3
Daylight	82A	Reduces the excessive warmth found in early morning and late afternoon light.	1/3
Type A	82A	To balance type A for 3220 K lights.	1/3

NOTE: 81 filters are yellowish, whereas an 82 is a bluish filter.

Color Compensating Filters. Color compensating filters come in pale tints of red, green, blue, magenta, yellow, and cyan. They are used to make very subtle color changes. A very large selection of densities are available, as shown in table 5-2. For this reason color compensating filters are available in gelatin sheets.

Special Filters. Special filters have been designed for specific type light balancing problems. The following list will indicate a couple of filters that are available.

Film Type	*Filter*	*Purpose*	*F/Stop Increase*
Daylight	FLD	Eliminates the blue-green cast which results when shooting daylight film under fluorescent lighting.	1
Type B	FLB	Used when shooting type B film under fluorescent lighting	1
Daylight	CC30R	When using daylight film underwater.	2 1/3

Exercise (642):

1. Which filter would you choose for each of the following situations?
   a. Shooting daylight film with tungsten lighting.

TABLE 5-2
TYPICAL COLOR-COMPENSATING (CC) FILTERS

Filter Nomenclature	*Color*	** Color Density*	*Exposure Increase in Stops*
CC 025 R		0.025	—
CC 05 R		0.05	1/3
CC 10 R	Red	0.10	1/3
CC 20 R		0.20	1/3
CC 021 G		0.25	—
CC 05 G		0.05	1/3
CC 10 G	Green	0.10	1/3
CC 20 G		0.20	2/3
CC 025 B		0.025	—
CC 05 B		0.05	1/3
CC 10 B	Blue	0.10	1/3
CC 20 B		0.20	2/3
CC 025 Y		0.025	—
CC 05 Y		0.05	—
CC 10 Y	Yellow	0.10	1/3
CC 20 Y		0.20	1/3
CC 025 C		0.025	—
CC 05 C		0.05	1/3
CC 10 C	Cyan	0.10	1/3
CC 20 C		0.20	1/3
CC 025 M		0.025	—
CC 05 M		0.05	1/3
CC 10 M	Magenta	0.10	1/3
CC 20 M		0.20	1/3

Note: * All the above filters are also available in additional densities of .30, .40, and .50. If filters are used in combination, exposure increase should be obtained by trial and error.

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b. Using type A film in daylight.

c. Shooting type A film with 3200 K lamps.

d. Using type B film with photofloods.

e. Using clear flash with type A film.

f. Shooting type B film under fluorescent lights.

g. Using daylight film underwater.

h. When shooting daylight film indoors with electronic flash.

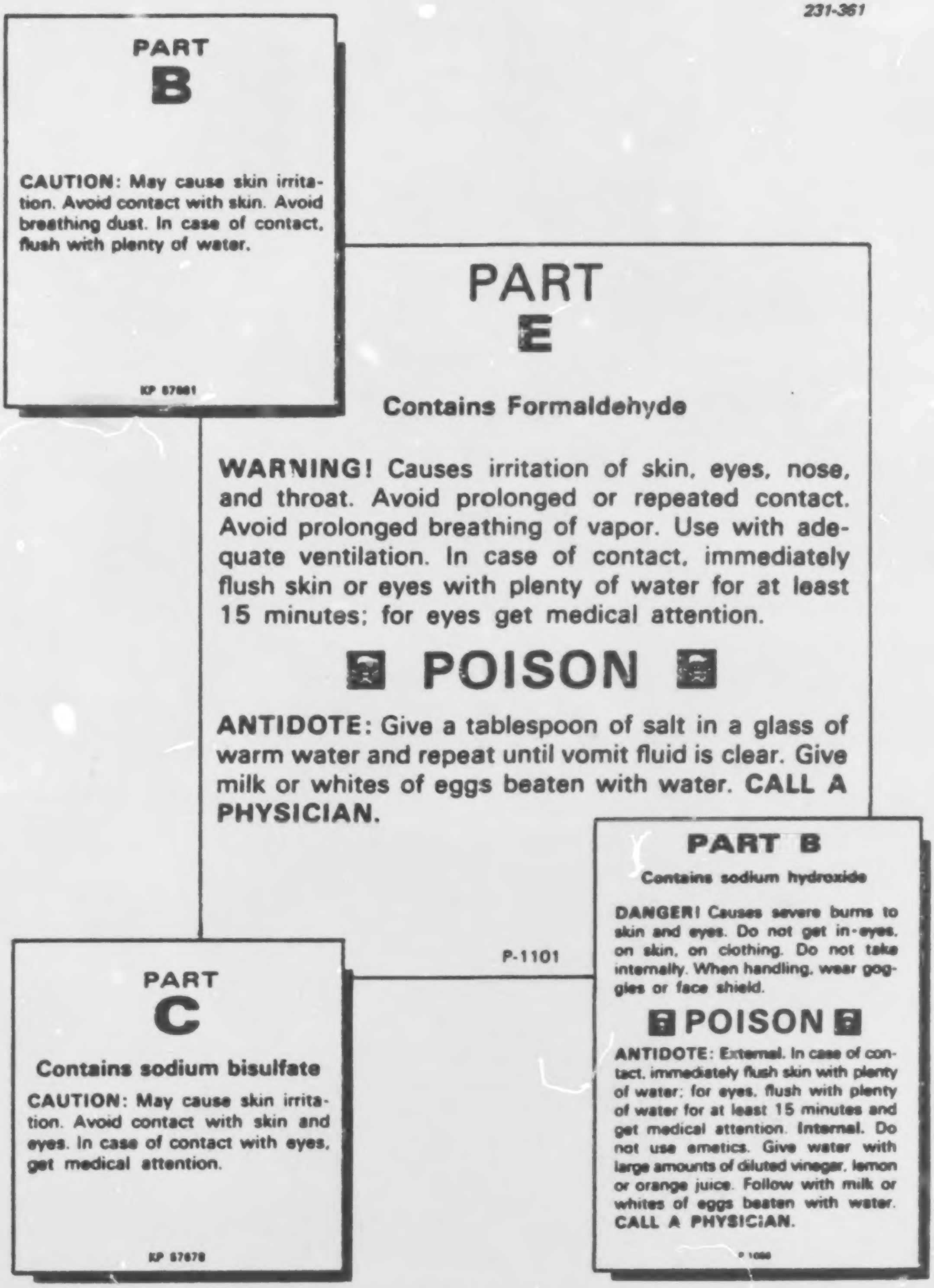
i. Shooting daylight film with clear flash.

j. Shooting daylight film in the early morning.

5-5. Mix Color Chemistry

Manufacturers of color film prepare processing kits that contain all the chemicals necessary to develop their product. It is therefore important to match the right chemical kit with the film you are using. These prepared kits are available in many different sizes to meet your requirements. By choosing the right size kit for the amount of film you have to process, you can prevent waste.

In this section we talk about mixing the chemical



PART B

CAUTION: May cause skin irritation. Avoid contact with skin. Avoid breathing dust. In case of contact, flush with plenty of water.

PART E

Contains Formaldehyde

WARNING! Causes irritation of skin, eyes, nose, and throat. Avoid prolonged or repeated contact. Avoid prolonged breathing of vapor. Use with adequate ventilation. In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes; for eyes get medical attention.

POISON

ANTIDOTE: Give a tablespoon of salt in a glass of warm water and repeat until vomit fluid is clear. Give milk or whites of eggs beaten with water. CALL A PHYSICIAN.

PART C

Contains sodium bisulfate

CAUTION: May cause skin irritation. Avoid contact with skin and eyes. In case of contact with eyes, get medical attention.

PART B

Contains sodium hydroxide

DANGER! Causes severe burns to skin and eyes. Do not get in eyes, on skin, on clothing. Do not take internally. When handling, wear goggles or face shield.

POISON

ANTIDOTE: External. In case of contact, immediately flush skin with plenty of water; for eyes, flush with plenty of water for at least 15 minutes and get medical attention. Internal. Do not use emetics. Give water with large amounts of diluted vinegar, lemon or orange juice. Follow with milk or whites of eggs beaten with water. CALL A PHYSICIAN.

Figure 5-9. Chemical warnings.

kits, quality control, storage, and safety. The main point to remember is that by following the manufacturer's directions you can turn out a good product.

643. State the principles and procedures related to the mixing and storing of color chemistry.

Mixing the Solutions. Before mixing any chemicals, check your water supply. Always use clean, sediment-free water. It may be necessary to filter the water to get rid of unwanted particles, but usually tap water is free of sediment. In some areas the water supply may contain an excess of sulphur or iron. If this is the case, it may be necessary to use distilled water.

The water must be at the recommended temperature for mixing. The mixing temperature is likely to be higher than the processing temperature so read the directions carefully. Mixing should be done in proper stainless steel or rubber tanks to prevent corrosion. Remember that the tanks must be spotlessly clean prior to pouring in the water.

When you mix chemicals, it is preferable to follow the order in which the solutions are used. This minimizes contamination of solutions. Sloppy techniques in measurement or mixing will produce chemistry that gives off-color results. It is, therefore, very important that each mixing step be carefully followed.

Quality Control. Quality control in color work is even more important than in black-and-white processing. Specific gravity, pH, and sensitometric testing should be performed and results compared against an established standard. These techniques will be explained in the next chapter, but it is important to remember that they apply to color work as well as black and white.

Storage. The processing kits obtained from the manufacturer do not require special storage consideration, because the chemicals are in cans, packages, or bottles. Any reasonable storage conditions which are free from extremes of temperature or humidity should prove satisfactory. This situation changes, however, after you put the chemicals into solution.

For best results, all solutions should be freshly mixed and immediately used. Unused solutions may be kept several weeks, provided they are stored in full, well-stoppered, amber-colored bottles. Bottles should be full, because airspace at the top permits excessive oxidation. Quantity production labs use large tanks with floating lids.

To get the most out of your chemicals, it is a good idea to coordinate your mixing with your shooting schedules so that you can process as much film as possible with freshly mixed chemicals. It is not, however, a good idea to keep color film piling up in order to have enough to process. Color film that is held up for processing may have color shifts which will lead to useless results.

NOTE: It is essential for good results that all containers be properly labeled and dated. It is also a good idea to have record sheets indicating how much materials have been processed. Such data will help you determine when the solutions should be replenished or dumped.

Handling of Color Chemicals. Figure 5-9 illustrates some of the caution markings found on chemical containers. Be sure to abide by such warnings. They are not to be treated lightly. Some color processing chemicals may only produce an inflammation of the skin after prolonged exposure, but others can be quite dangerous if they are mishandled.

The best insurance against problems caused by chemicals is a laboratory and personal program of contact prevention. Many problems stem from the fact that you handle fairly large quantities of hazardous liquids, solvents, and solids. Even in small quantities, some of these are hazardous. We shall list general precautions. Your lab has many additional specific handling precautions and procedures. You will find that one of the more effective preventive measures is cleanliness.

Handling liquids. Some of the major precautions in liquids and solvents handling are listed below. Remember, these are generalized statements that may not include the specific measures established for your lab.

a. Keep working areas clean and free from spilled solutions.

b. Wear rubber gloves, protective clothing, and tight-fitting goggles—especially when handling large quantities of liquids or any amounts of hazardous liquids.

c. Dispense liquids from drums by means of mechanical pumps or metering devices.

d. Take care in opening containers. Never leave them open.

e. Do not store concentrated acids, alkalies, or irritants in open containers.

f. Store large containers of hazardous liquids on or near the floor.

g. Store flammable solvents in approved containers and away from ignition sources. Store them at electrical ground potential by employing a grounding wire. Observe "no smoking" regulations.

h. Do not breathe (or contact) vapor from solvents such as formaldehyde, enthylene chloride, chloroform, and benzyl alcohol. Provide forced air ventilation as required; for example, over the tanks of processing machines or other areas where these vapors exist.

i. Always add acid to water, never water to acid.

j. Know the location of emergency body and eye showers and how and when to use them.

Handling solids. The principles of handling solids safely are basically the same as those of handling liquids and solvents safely; that is, you should avoid

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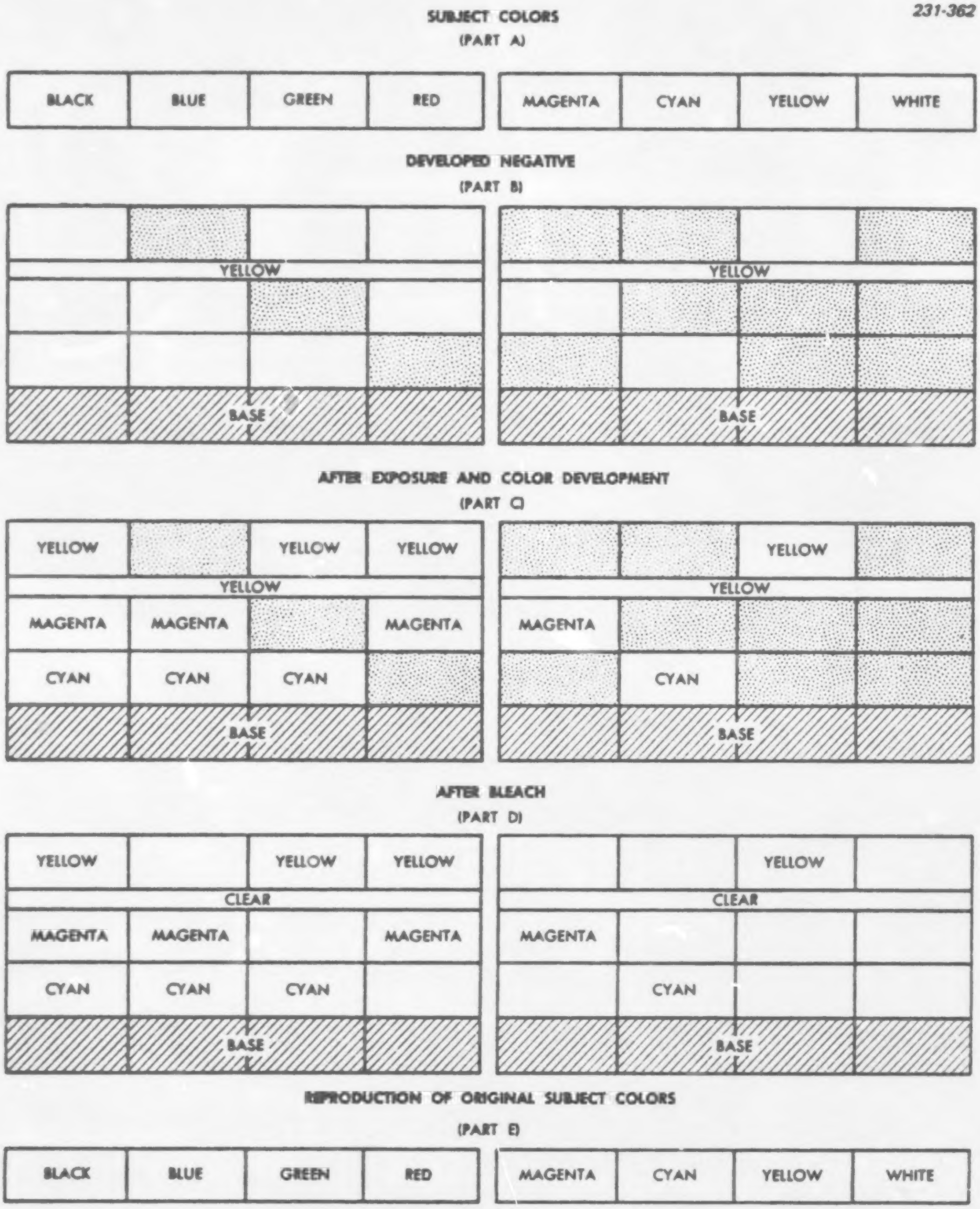

Figure 5-10. Dye formation.

skin contact and inhalation. Keep chemicals off the skin, out of the eyes, lungs, and stomach. Such avoidance is largely accomplished by means of personal protective measures, mechanical handling, proper storage and transport, use of ventilation hoods, and clothing/area cleanliness.

Perform all bulk weighing and container-to-container transfer under a vented weighing hood so that chemical dust is removed before it can fall on your clothing or be inhaled. Keep the area clean, wear gloves and goggles, and change clothing frequently. Clothing cuffs catch chemical dust and are the most frequent cause of difficulty.

Problem-causing color chemicals. Even if you are not concerned with mixing up large quantities of color processing chemicals, there is still a good chance of contact with them. If you get color developer, bleach, or stabilizer on your hands, immediately wash your hands. If your hands are chapped or cut, or if the skin is sensitive for some other reason, the chemicals can penetrate faster and compound the problem.

Color developers are especially active skin sensitizers and can cause dermatitis (skin inflamation) for practically all those who handle them carelessly. The formaldehyde in a stabilizing bath and the potassium dichromate in a bleach bath are also chemicals that cause dermatitis. If any itching, burning, redness, or swelling occurs around your nails or between your fingers, see a doctor as soon as possible. Do not continue working and do not try to doctor yourself.

Exercises (643):

1. What type of water should be used to mix color chemistry?

2. At what temperature should the water be for mixing?

3. In what order should chemicals be mixed?

4. Proper chemical storage will help prevent what problem?

5. What is the best way to prevent dermatitis?

6. Where should a container of hazardous liquid be stored?

7. What should you do if your hands get soaked in color bleach?

5-6. Processing Color Film

So far you have studied the types of color films and how to expose them, and you have learned certain general principles on how to prepare the chemistry for processing. In this section you will be given an overview on what must take place to produce a color image and the steps in processing reversal and negative color films.

644. Complete statements on the basic principles of color processing.

Formation of the Dye Image. Color films are basically multi-layer black-and-white films at the time of exposure. In fact color film can be processed in a black-and-white developer to produce a negative that can be printed in the normal manner. It is only when color film is processed in a color developer that color dyes are formed to give you color.

To understand the importance of this idea, let us study the basic steps in the exposure and processing of reversal color film. First refer to figure 5-10, so that you can follow the process of exposing and processing the film. Notice that the blocks labeled "Subject Colors" in part A include both the primary and secondary colors. Consider these blocks as though each one was a separate object so that it is somewhat easier to follow the results from one area to another.

Now let us begin. Suppose we expose film in our camera using this series of color blocks as our subject. Light makes an exposure on the film in the appropriate layers. The film is then developed (First Developer) to a negative image, as shown in part B. Notice that silver halides are exposed only in the sensitive layer which corresponds to the color of the object. For example, a blue object exposes the top blue-sensitive layer and none other. After development, the silver halides in this area are reduced to black metallic silver. Note that the secondary colors expose two layers, black none, and white exposes all layers.

Following the first development (and necessary stop bath, hardener and rinse), the film is exposed to white light. This exposure fogs the remaining silver halides which were not affected by camera exposure. (In some processes like Kodak's E-4, this reexposure is done by chemical means rather than actually exposing the film to light.) The film is then processed in the color developer and appears as in part C. The silver halides that were exposed during the second exposure are fully developed now. During color development, a strange event happens. In addition to other chemical changes which take place, colored dyes are formed. These colors are secondary colors that combine to reproduce the colors of the original subject. This is based on the subtractive color principle. By following what has happened to our blue subject, you can see that following reexposure and color development that there has been the formation of magenta and cyan dyes. Passing white light through these two dyes will produce a blue image.

The final step of the process is illustrated in D. Up to this point we have produced three images: a black-and-white negative, a black-and-white positive, and a color dye image. Since the metallic images remain, the film appears opaque. Once the metallic silver has been bleached and fixed away by the remaining steps of the processing, only the dye image remains.

Once the silver has been removed and the transparencies have been dried, we can see the result of our processing. When we view a transparency by transmitted light, light is filtered through the dyes that have been formed. Using our original blue subject again for example, notice that in the blue area, white light must pass through what is effectively a magenta and a cyan filter. The combination of these two colors subtract all colors except blue. Magenta is blue and red; cyan is blue and green. Therefore, the magenta dye does not pass green, and the cyan does not pass red. The only color common to both is blue, so it will be the one transmitted. The result of all this selective filter action is a reproduction of the original subject colors as shown in part E.

The "gimmick" that made this possible was the formation of colored dyes during the second development. The principle involved in the process is called dye coupling. Each color-sensitive layer of a color emulsion contains, in addition to the silver halides, a chemical that is used as a coupler, which, when it comes into contact with another ingredient in the color developer (usually an amine or analine), forms a dye of a specific color. The union (or chemical action) between color-forming chemicals takes place only while development (or silver reduction) is occurring and oxidation products are being formed. This principle of color coupling is particularly well adapted to color photography, because color is not formed in any area where light action has not taken place. Most present-day color film processes operate on this principle. Because of the similar chemical structures of the various dye couplers, the film from one manufacturer can be processed in the chemicals from another company, but any results from this intermixing will likely be unsatisfactory. There is color, but many odd varieties may develop. Accordingly, the procedure is normally not recommended.

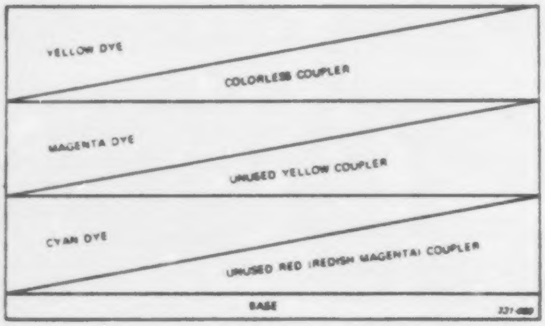

Figure 5-11. Negative color masking.

Color Negative Film. The basic difference between negative and reversal color processing is that negative film is processed in a single, color developer. There is no reexposure step or use of a black-and-white developer. The amount of dye produced is directly related to the exposure the particular film layer received during camera operation. In addition, color negative film uses colored couplers in forming the middle and lower dye layers. This last point requires some explanation.

Dye characteristics. After color film is completely processed, all that is left is the three different layers of dye. The primary purpose of these dyes is to control transmission and absorption of red, green, and blue light. However, the best available dyes produced in color film absorb some light which they should transmit. This is true in negative and positive color films since the dyes used are the same. For example, a perfect cyan dye would absorb only red light and would transmit green and blue light freely. All known cyan dyes, however, absorb fairly large proportions of green and blue light. Similarly, a perfect magenta dye would absorb only green light, transmitting blue and red light freely. Actually, magenta dyes transmit red light freely, but absorb some blue light. Of the three dyes used (cyan, magenta, and yellow), yellow is the closest to ideal. Yellow absorbs blue light and transmits green and red light.

The effects of the unwanted absorptions of the dyes are not a serious disadvantage in a positive color transparency which is to be used only for projection or viewing on a light table. The real difficulty is noticeable when a duplicate or a color print is made from the transparency. Since the dyes in the reproduction material are the same as the dye in the original, the errors are multiplied in the reproduction. In order to produce satisfactory results, supplementary masking must be used for correction of color.

If masking is not used, two types of errors will occur in reproduction. These errors are saturation and hue of colors. First of all, blues, cyans, and greens tend to be too dark, while reds, oranges, and yellows tend to be too light. Second, hue-shift errors occur. Reds usually shift toward orange, magentas toward red, and cyans and greens toward blue.

Masking to correct dye error. Color masks, which provide a neutralizing effect for unwanted dye absorption, are readily seen in the unexposed areas of a color negative. (See fig. 5-11.) There are two such masks: a yellow mask in the green sensitive (magenta dye forming) layer, and a reddish magenta mask in the red (cyan dye forming) layer. Together they produce an orange tint in unexposed areas. There is no need for a mask in the blue sensitive (yellow dye producing) layer, since the yellow dyes usually have negligible unwanted dye absorption.

The absorption of a mask corresponds to that of the dye layer for which it is made. For example, magenta dye (which should absorb only green) absorbs blue light. The yellow mask for this layer absorbs the same amount of blue light uniformly over the area of the negative except where magenta dye is produced. Thus, where mangenta dye is produced, the yellow mask is destroyed in an equal proportion. The result is elimination of color distortion because the unwanted absorption is uniform over the entire negative area. This is accomplished by using a colored dye coupler. An ingredient, quinone diimine, in the color developer reacts with this coupler to form magenta dye and destroys the yellow coupler. The red coupler for the cyan dye layer works in the same manner. The mask formation does not require any auxiliary treatment but forms automatically during color development and remains in the film after processing.

Exercises (644):

1. What type of image is formed in the first developer of the reversal process?

2. How is color achieved in color films?

3. What color dye is produced in each layer of color film?

4. List the images that are formed once reversal film has been processed through the two developers?

5. The amount of color dyes produced during the processing of color reversal film is directly proportional to the number of halides exposed during camera operation or during reexposure. Yes or no? Why?

6. If you photographed a red subject with reversal color film, what colored dyes would be formed during processing?

7. If you photograph a blue subject with negative color film, what dye(s) will be produced during processing? Why?

8. What colored couplers are used in color negative film? Why?

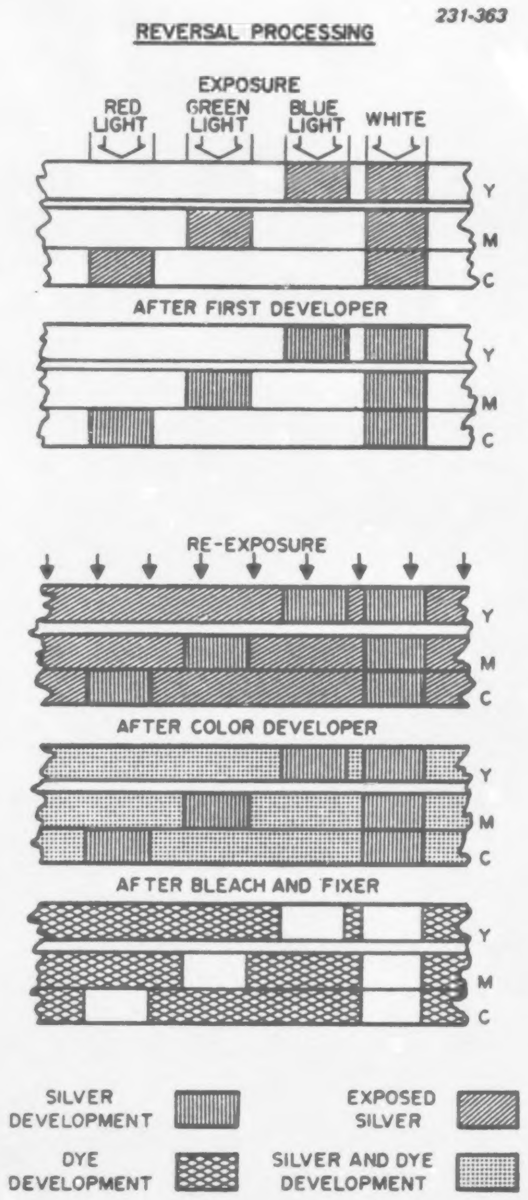

Figure 5-12. Reversal processing.

645. Outline and explain each step in the reversal color process.

Reversal Color Processing. In reversal color processing there are five major steps: first development, reexposure, color development, bleach, and fix. These major steps are illustrated in figure 5-12. It must be stressed, however, that the exact number of processing steps, their order, the necessary times, temperatures, and methods of agitation are very much dependent on the film/developer combination that you are using. With color processing, even more than in black and white, you must follow directions for consistent results. What follows is a brief description of what happens in the five major steps to give you a better understanding of reversal film processing.

First developer. The first developer is a very active black-and-white developer (similar to D-19). Its function is to produce a black-and-white negative image. The real trick is to expose and develop about one-half of the silver halides. If you do otherwise, too little or too much dye will be produced in the color developer.

NOTE: Processing in the first developer must be exact. Temperature must be within one-half degree of standard and time, and agitation must be on the "money."

Hardener stop bath. After the first developer, development is stopped by processing the film in a solution similar to an acetic acid stop bath. Since the first developer is alkaline, development will be arrested when the emulsion is placed in the acid bath. In Kodak's E-3 process, the stop bath and hardener are combined in one solution. A hardener is necessary, because the emulsion is extremely soft. If the film isn't hardened, it may be damaged by abrasions, or it may be subject to further softening and separation from the base during subsequent steps. Room lights can be turned on after the developer has been completely neutralized.

Reversal exposure. This second or reversal exposure serves two purposes. First, it produces a positive latent image; and second, it forms the basis for the production of the colored dyes. The amount of dyes produced in the color developer are directly proportional to the number of halides fogged (exposed) during reexposure. The reversal exposure time isn't critical except that it must be complete. The usual method is to expose the film to a photoflood lamp for at least 30 seconds a side.

CAUTION: Photoflood lamps and similar lighting can get very hot. A bulb could shatter if splashed with liquid.

NOTE: As mentioned before, in some processes like Kodak's E-4, reexposure is accomplished by chemical means.

Color developer. The color developer performs two functions. First, it reduces the halides exposed during reexposure to black metallic silver forming a silver positive image. Second, chemicals in the color developer react with the ingredients in the different emulsion layers to form the different color dyes (positive dye image). The formation of the dyes and the reduction of the silver take place simultaneously and are directly related.

TABLE 5-3
E-3 PROCESSING STEPS

Ektachrome—Process E-3

Solution or Procedure	***Remarks*	**Time in minutes*
1. First Developer	Agitate as prescribed for equipment used.	10 min. at 75° F. ± ½° F.
2. Rinse	Agitate continuously for the first 15 seconds in running water.	1
3. Hardener	Agitate continuously for the first 15 seconds.	3
Remaining steps can be done in normal room light.		
4. Wash	Running water	3
5. Reversal Exposure	Re-expose as prescribed for equipment used. Films must receive at least 1-minute drain before color development	
6. Color Developer		15
7. Wash	Running water	5
8. Clearing Bath		5
9. Rinse	Running water	1
10. Bleach	See warning on label.	8
11. Rinse	Running water	1
12. Fixing Bath		6
13. Wash	Running water	8
14. Stabilizer	See warning on label.	1
15. Dry	Not over 110° F. with same methods as black and white.	

*All processing except step No. 1 at 73° to 77° F.

**Agitate once each minute by (1) lifting rack clear of solution, (2) tilting it 60° in one direction, (3) reimmersing it, (4) lifting the rack clear again, (5) tilting it 60° in the opposite direction, and (6) reimmersing it. Timing: Include drain time (10 seconds) in time for each processing step.

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Bleach. Bleaching is always the next major step after color development. The purpose of the bleach is to convert all the silver, including the yellow collodial silver layer, into soluble compounds that can be fixed away. Inadequate bleaching will result in residual silver density which will affect the transmission of light.

Bleach is a very strong solution. It must be maintained in stainless steel, glass, or appropriate plastic containers. Also, many technicians wear rubber gloves when working around bleach because its corrosive qualities are quite damaging to the skin.

Fixing bath. The fixing bath serves a couple of functions. First, the soluble salts formed in the bleaches are absorbed into the fixing bath. The bath prevents any stains that might be caused by having bleach remain on the film. Finally, it acts as a safety factor by removing any possible residual unexposed silver halides that might be in the film.

In addition to these five basic steps, there are several other steps common to color processing. Between many main steps will be a rinse or wash step. A wash step is used to reduce possible contamination caused by carryover of chemicals from one chemical solution to another. A long final wash (example: 8 minutes following the fixing bath) is used to remove all chemical residue. Removal of chemical residue is necessary in order to prevent discoloration and stains. Normally, the last step of the processing prior to drying is a stabilizer step. The stabilizer is primarily a wetting agent with formaldehyde added. The wetting agent prevents water drops from forming during drying, and the formaldehyde prevents fading of the dyes and acts as a hardener. Drying which follows processing should be done in a very clean film dryer not set above 110°F. (See table 5-3 for a summary of the Kodak E-3 steps.)

NOTE: You should carefully study your transparencies for any processing defect. Stains and other problems should be carefully noted and their cause discovered. Almost all manufacturers of film and developers for color work have charts which indicate the cause for the basic problems you might encounter. (See table 5-4 for an example of problems arising from Ektachrome processing.)

TABLE 5-4
PROCESSING ERRORS

"Ektachrome"	
Fault	*Probable Cause*
Bluish or blue-green cast	Temperatures too low or processing times too short.
Reddish cast	Wash water after color developer contaminated with bleach.
Orange cast	Film not cleared and fixed after bleach.
Deep red cast	Film not washed, cleared, and fixed after bleach.
Magenta cast	Insufficient wash after color development.
Bluish to purple in average to high densities	Color developer improperly mixed.
Low density shadows with green or cyan coloring	Solutions saved too long or exhausted.
Greenish cast in heavy densities	Incomplete reversal.
Greenish cast with darkened red	Contamination of color developer with clearing and fixing bath.
Colors tend to shift after film has dried a few days	Insufficient bleaching or an exhausted bleach solution.
Gray-white streaks or scum	Insufficient rinse after the first development.
Orange veiling over film	Fogging during first development. *231-699*

Exercise (645):

1. Outline and briefly explain the five major steps in reversal film processing.

646. Outline and explain each basic step in the negative color process.

Color Negative Film Processing. Three major steps are necessary in processing color negative film. The major processing steps are color development, bleach, and fix. These three steps are illustrated in figure 5-13.

Upon camera exposure, a latent image is formed within the three emulsion layers of color negative film To start processing, the film is immersed in a color developer. Two images are formed in this solution: a negative silver image and a negative dye image. The amount of dye produced is directly proportional to the amount of silver reduced in forming the silver image. Since two images cannot be tolerated, one must be removed. As is the case in the reversal process, the bleach bath prepares the silver and the collodial layer for removal. Now the film passes through a fixing bath to remove the now soluble compounds. The result is a negative color dye image along with the appropriate color couplers. Because this is negative color, it must be printed onto a print material to form a positive image.

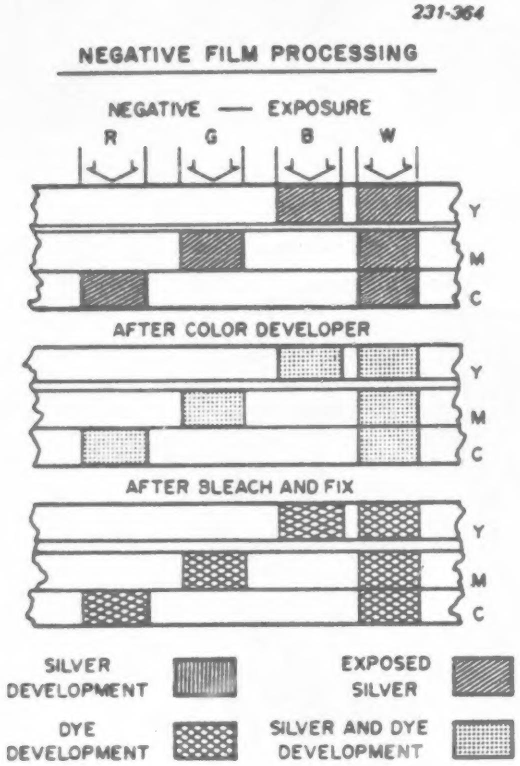

Figure 5-13. Basic steps of processing color negative film.

By way of example, table 5-5 gives you the steps for Kodak's C-22 process of negative color film. The principle of each step is the same as discussed in the section on reversal processing. Remember, as always, consult the particular data sheet for the film/developer combination you are working with.

Exercise (646):

1. Outline and briefly explain the three basic steps in negative color film processing.

5-7. Print Color Materials

The production of a fine color print is for many the ultimate in photography, and for years such production was also the most difficult to achieve. However, with the introduction of good color negative films and paper and with the simplification of color print processing, color printing has become as flexible and practical as black-and-white printing. A tremendous additional advantage of working with color negatives is that, in addition to color prints, you can produce color transparencies, black-and-white prints, and separation positives for photomechanical reproduction. You also can make good color prints from color transparencies by first making an internegative or by using a direct reversal paper process.

Good color prints are not difficult to make. Anyone who has normal color vision and who is willing to follow instructions can learn to make good color prints.

647. Name and explain the use of equipment and materials used in color printing.

The equipment necessary for color printing is similar to that required for black and white. You need an enlarger, printing paper, darkroom facilities, and equipment for processing. In addition, you need a set of color printing filters. Let us discuss a typical color enlarger and an example of the type of color printing paper you might be using.

Chromega D-4 Projection Printer. The Chromega is a table-sized diffusion type autofocus projection printer designed for making color enlargements from photographic negatives ranging in size from 35mm through 4x5 inches. The projection printer may also

TABLE 5-5
THE C-22 PROCESS

Step and Solution	*Precaution***	*Time* in minutes*
1. Developer	Total darkness	14
2. Stop Bath	Total darkness	4
3. Hardener	Total darkness	4
Remaining steps can be done in room light		
4. Wash	Running water	4
5. Bleach	Read warning on label	6
6. Wash	Running water	4
7. Fixing Bath	**	8
8. Wash	Running water	8
9. Final Rinse	Use solution of wetting agent	1
10. Dry	Remove film from hangers or reels to dry. Not over 110° F.	

* All processing except step No. 1 at 73° to 77° F.
** Agitate once each minute by (1) lifting rack clear of solution, (2) tilting it 60° in one direction, (3) reimmersing it, (4) lifting the rack clear again, (5) tilting it 60° in the opposite direction, and (6) reimmersing it. Timing: Include drain time (10 seconds) in time for each processing step.

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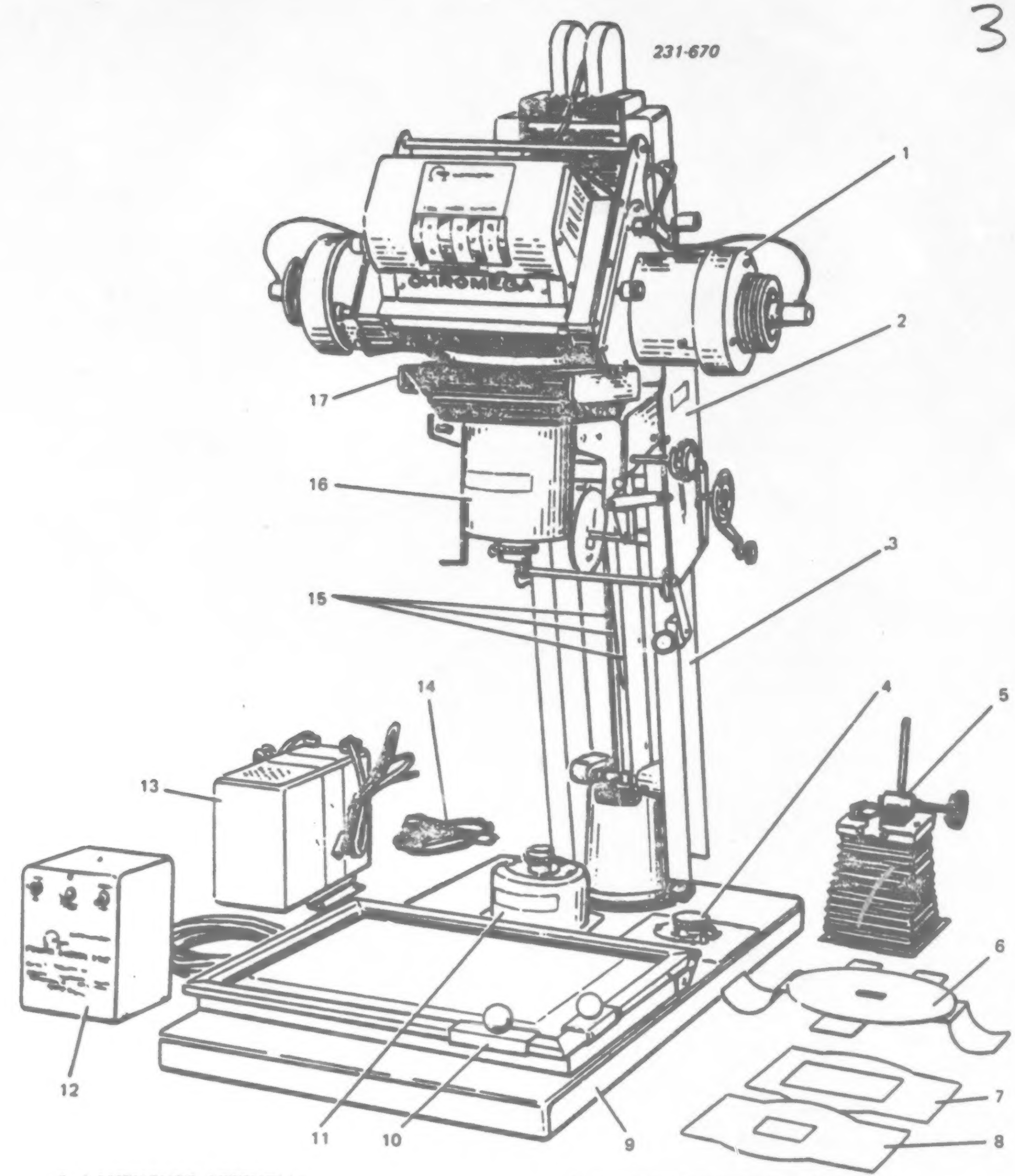


1. LAMPHOUSE ASSEMBLY
2. CARRIAGE ASSEMBLY
3. GIRDER ASSEMBLY
4. 50-mm LENS AND LENS MOUNT ASSEMBLY
5. AUXILIARY FOCUSING ATTACHMENT
6. 35-mm RAPID SHIFT NEGATIVE CARRIER
7. 4 by 5 IN. CUT FILM GLASSLESS NEG. CARRIER
8. 2¼ by 2¼ IN. GLASSLESS NEG. CARRIER
9. BASEBOARD ASSEMBLY
10. PROJECTION PRINTING EASEL
11. 105mm LENS AND LENS MOUNT ASSEMBLY
12. POWER SUPPLY UNIT
13. VOLTAGE STABILIZER
14. TIMER CONNECTING CABLE
15. CAMS
16. 150mm LENS AND LENS MOUNT ASSEMBLY
17. 2¼ by 2¼ IN. RAPID SHIFT NEG. CARRIER

Figure 5-14. Autofocus photographic projection printer.

be used for the exposing of black-and-white prints. (See fig. 5-14.)

Major components of the Chromega are as follows: 50mm f3.5, 105mm f4.5, and 150mm f4.5 lens and lens mount assembly—each with a matching cam.

The lamp house assembly consists of two lamps and light collectors, two motor operated blower systems, an integrating sphere, and a removable color control unit.

The lamps and light collectors are inside the two ventilating spinnings which are mounted on the sides of the lamp house. Each ventilating spinning contains a lamp, a light reflector, and a heat absorbing glass assembly. A motor-operated blower, mounted behind each ventilating spinning, functions to cool the heat absorbing glass.

The integrating sphere is set in the center of the lamp house assembly. Positioned between the two light collectors, the sphere receives, diffuses, and directs the light toward the negative to be enlarged. A white matte coating on the concave interior multiplies the reflection of the light from the lamps within the sphere. This multiple reflection diffuses the light and spreads it uniformly over the negative.

The color control unit consists of two sets of three color filter wheels which are geared to three dial indicators. (See fig. 5-15.) The color filter wheels contain graduated segments of filter material in the three subtractive colors: cyan, magenta, and yellow. The color segments are set on the wheel in overlapping sizes ranging from 4 sections to 1 section. This staggered arrangement enables the operator to control the extent of color filtration by manipulating the three color control knobs mounted on the sides of the filter housing.

The density of color filtration is registered on the three dial indicators which are set in the front of the color control unit. The dial indicators permit continuous filtration from 0 through 180. Both the color filter control knobs and the dial indicators are covered with tape which is colored to correspond to each color. The entire color control unit may be swung out on the pivot bar and lifted away from the rest of the lamp house assembly.

The carriage assembly consists primarily of two side plates which may be raised or lowered by operating a handwheel, while two balance springs attached to the girder assembly function to counteract the weight of the carriage. Two carriage arms attached to the side plates of the carriage assembly support the film stage and the bellows assembly. A carriage brake knob locks the carriage assembly in place on the girder.

The lamp house is supported by one long lifting lever and three short lifting levers. The long lifting lever serves to raise and lower the lamp house assembly to permit the transportation of film and the removal of the photograph negative carrier.

The bellows is raised or lowered by the action of the focusing mechanism against a focusing shaft. As the cam follower wheel moves over the cam, motion is transmitted through the forkplate to the two lens leveling plates.

A focusing knob permits manual focus adjustment. After an initial manual adjustment, the cam follower wheel will maintain the correct focus between negative and enlarger for all carriage positions. When it is desired to shift the cam follower wheel from one cam to another, a brace allows the wheel to be raised away from the cam. A spring-loaded lock holds the cam follower wheel in place; this lock must be actuated before lifting the wheel.

NOTE: The configuration of the cams has been computed for use with an easel exactly 1 inch thick.

The girder assembly forms a rigid support for the carriage assembly. Gear racks behind the girder channels provide for raising and lowering the carriage. Two balance springs, mounted on top of the girder and attached to the carriage assembly, counterbalance the weight of the carriage and the lamp house assemblies.

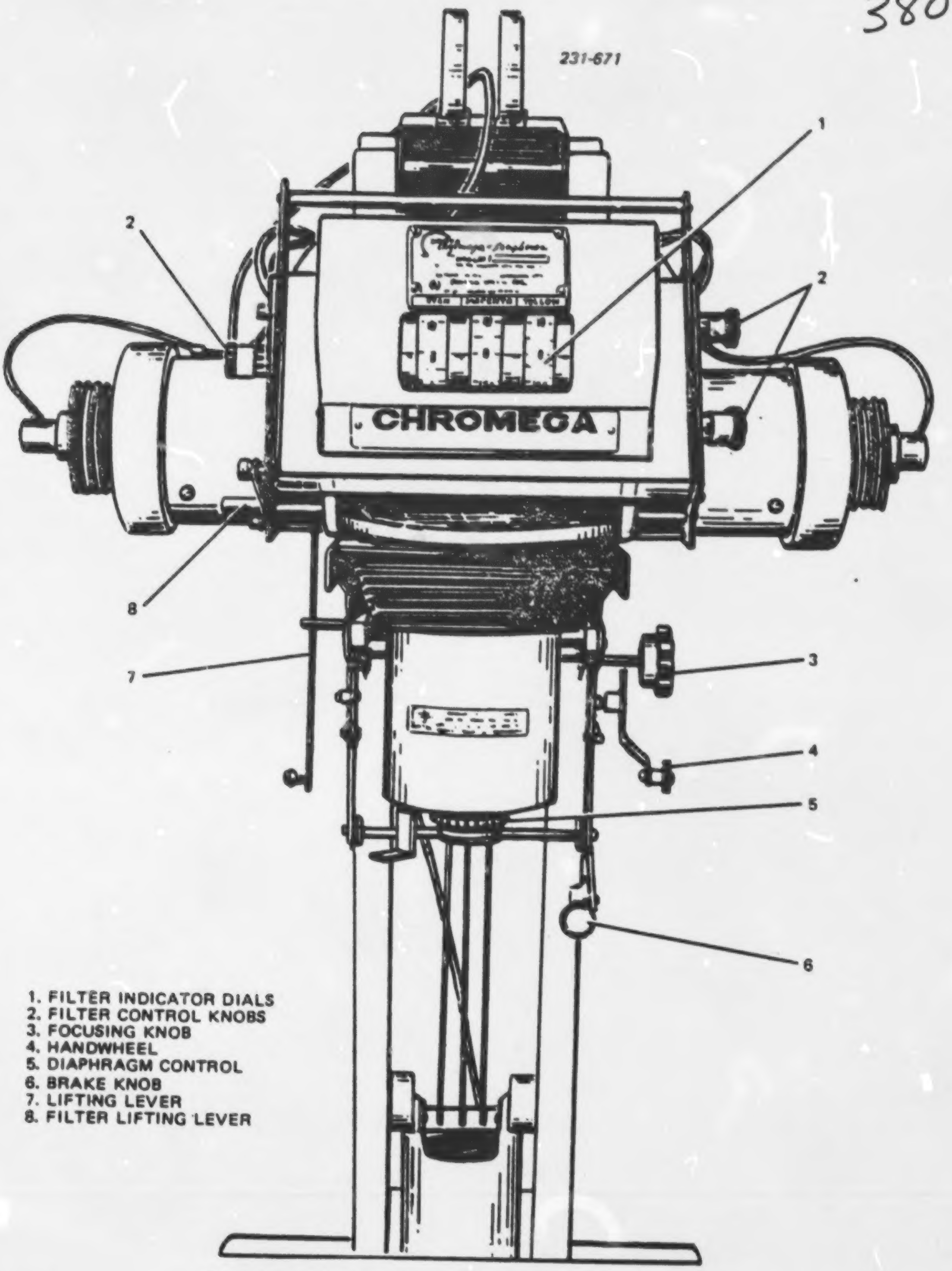
The baseboard assembly consists of a wooden baseboard and a steel baseboard plate that form the mounting support for the girder assembly. Three rotary clamping pads secure the girder assembly to the baseboard.

A projection printing easel, which will accommodate paper up to 11 by 14 inches, is supplied with the projection printer.

Two sandwich-type photograph negative carriers and two rapid shift photographic negative carriers are supplied with the projection printer. The sandwich types are a $2\frac{1}{4}$- by $2\frac{1}{4}$-inch glassless and a 4- by 5-inch cut film glassless. The rapid shift negative carriers of the 35mm glassless are the $2\frac{1}{4}$- by $2\frac{3}{4}$-inch glassless type.

The power supply unit is designed for use with a 110- to 117-volt ac, 50- to 60-cycle power source. The unit contains a stepdown transformer to supply current for the lamps and blower motors. Two lever switches and a lamp replacement indicator lamp are set in the front plate of the unit. The ON-OFF switch is on the upper left of the front plate; it functions to activate the projection printer and start the motor-operated blowers. The FOCUS-PRINT switch is a double throw switch located on the upper left of the front plate. When this switch is set in FOCUS position, it energizes the lamps in the lamp house; when it is set in PRINT position, it prepares the projection printer for making the exposure. The lamp replacement indicator lamp is connected to ground through a 10-watt, 5-ohm resistor. If one of the two lamps in the lamp house fails to light, the current will overcome the resistance and flow to ground; and the lamp replacement indicator lamp will light. A recessed male connector, a female connector, and a six-prong connector receptacle are set in the rear plate of the power unit supply. A 12-foot long timer connecting cable is supplied with the power supply unit for connecting it to the timer unit.

A voltage stabilizer (constant voltage regulator) is



1. FILTER INDICATOR DIALS
2. FILTER CONTROL KNOBS
3. FOCUSING KNOB
4. HANDWHEEL
5. DIAPHRAGM CONTROL
6. BRAKE KNOB
7. LIFTING LEVER
8. FILTER LIFTING LEVER

Figure 5-15. Projection printer operation controls and indicators.

supplied as an accessory to the projection printer. It is rated at 250 watts, 60 cycle, 117 volts input and 117 volts output. The stabilizer should be used in any location where the line voltage is not kept constant. Voltage stabilization is necessary to insure a constant color temperature.

Operational procedures are as follows:

1. Set the cam follower wheel on the cam that is matched with the lens being used. This insures automatic focusing with the lens you are using.

NOTE: Matching cam and lens are identified by the matching part number which is inscribed on the lens and on the cam identification plate.

2. Insert the appropriate sized negative carrier by raising the lamp house and installing the negative carrier on the film stage.

3. Turn the filter lifting lever upward and lift the filter housing away from the path of the light beam.

4. Turn the diaphragm control counterclockwise and open the lens aperture as wide as possible. Then turn the handwheel and raise the carriage assembly to its highest point.

CAUTION: Do not attempt to turn handwheel without first loosening the brake knob, or damage to the carriage gears may result.

5. Set the ON-OFF switch to the ON position and set the FOCUS-PRINT switch to the FOCUS position.

6. Place a sheet of white paper in the projection printing easel and adjust the focusing knob until a sharp focus is maintained.

NOTE: Once established, the image sharpness will remain unaffected by any subsequent raising or lowering of the carriage assembly.

7. Lower the filter housing and adjust the filter control knobs for the desired color filtration.

8. Turn the handwheel and lower the carriage assembly until the desired enlargement size is projected onto the white paper in the easel. Then tighten the brake knob.

9. Adjust the diaphragm control to the desired f/stop.

10. Adjust the easel masking plates until the desired enlargement image is within the area indicated by the masking blade arms.

11. Set the FOCUS-PRINT switch to the PRINT position and replace the white paper in the easel with a sheet of sensitized paper.

12. Make the exposure. The exposure time must be calculated by the f/stop setting, the type of sensitized paper, the density of the negative, and the degree of magnification.

Color Print Paper. Color printing paper is a tripack reflection type print material with the emulsion sensitivity of the three layers reversed from that of most color materials. The top layer is sensitive to red; the middle to green; and the bottom to blue light. In this case a collodial silver layer to filter blue is not used as it is in many other color materials. Instead each emulsion layer is designed to be monochromatic; that is, primarily sensitive to one color only. Of course no orange masking, such as that found in color negatives, can be used since the print is to be viewed.

As in other color materials you have studied, the color of the dye formed in each emulsion layer during processing is complementary to the color sensitivity of the layer. Thus, the original subject colors are reproduced in the print. The system works this way. The colors reproduced in a color negative are complementary to the original primary subject colors. A red barn, for example, is cyan in the negative. Cyan is a combination of blue and green; therefore, the two emulsion layers (in the paper) that are sensitive to blue and green are affected when the negative is printed. Then, during processing, yellow dye forms in the exposed portion of the blue sensitive layer, and magenta dye forms in the exposed portion of the green sensitive layer. Yellow and magenta in combination produce red. Therefore, the red barn is reproduced in its original color. All of the other colors follow a similar pattern.

Color print papers are available in a variety of sizes, weights, and finishes. They all come with quite specific directions as to use. These instructions must be carefully understood for best results.

Storage and Handling of Color Printing Paper. High temperatures or high humidity can cause undesirable changes in the speed and color balance of color print paper. Color paper should be kept in the original sealed package in a freezer at about 50°F or lower. (For long term storage the paper should be kept at 0° to −10°F.) The paper should be taken out and then be allowed to warm up to 70°F prior to use. Any unused paper should be returned to its package. Make sure you restore the moisture barrier around the unused paper by pressing out the excess air, remaking the double fold at the end of the bag, and securing it with masking tape. Return the package to the refrigerator immediately. Do not freeze.

For best results it is important to process an exposed print as soon as possible. If exposed paper must be kept overnight prior to processing, it should be packaged and refrigerated. Remember that the paper should be allowed to warm up to 70°F prior to processing.

NOTE: As has been emphasized before, consult the manufacturer's directions for specific handling and storage procedures.

Exercises (647):

1. What is one feature found in a color enlarger that is not found in a black-and-white enlarger? Why?

2. Is a Chromega a condenser or diffusion type enlarger?

TABLE 5-6

FINAL CHANGES IN FILTER PACK

If Previous Print is Too:	Amount of Change Desired		
	Very Slight	Slight	Considerable
RED	add 05M + 05Y	add 10M + 10Y	add 20M + 20Y
GREEN	subtract 05M	subtract 10M	subtract 20M
BLUE	subtract 05Y	subtract 10Y	subtract 20Y
CYAN	subtract 05M + 05Y	subtract 10M + 10Y	subtract 20M + 20Y
MAGENTA	add 05M	add 10M	add 20M
YELLOW	add 05Y	add 10Y	add 20Y

NOTE: Add 10 percent to the exposure time for each filter added. Subtract 10 percent for each filter removed.

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3. What is the largest size negative that can be handled by a D-4 Chromega?

4. What focal length lens would you use when enlarging 120 film?

5. What mechanism controls the raising and lowering of the Chromega's bellows?

6. What is the purpose of a voltage stabilizer? Why is such a device important in color printing?

7. What color of light is recorded and which dye is formed in each layer of color paper?

8. A blue automobile on a color negative would be recorded in what layer(s) of color paper?

9. Prior to using color paper, you should allow it to reach what temperature?

648. State principles and explain techniques of color printing exposure.

Exposure Methods. You may expose color print paper by either of two methods: tricolor or white light. The tricolor method requires three successive exposures through red, green, and blue filters. This "additive" exposure method necessitates perfect registration between the printer and the paper for each exposure. This is a time-consuming method, though there are claims that this method produces the best color rendition. The white light or "subtractive" method requires a single exposure with appropriate color printing (CP) or color correction (CC) filters of cyan, magenta, and yellow mixing the right color quality for best results. This method is the one used by the Air Force.

Trial and error exposure determination. (Kodak Ektacolor 37 RC paper is used as an example for this section. The principles involved can be applied to other types of paper. Be sure to read the necessary instructions that accompany the material you are using.) Ektacolor 37 RC paper is balanced so that for an average Ektacolor S negative a starting filter pack of 50 M (magenta) and 70 Y (yellow) is used. (If you would add cyan to this pack you would only be getting neutral density.)

With the negative and the starting filter pack in place (plus the standard CP2B filter which should be permanently installed above the negative carrier), you make a test-strip series of four exposures at the same magnification that is to be used for the final print. Expose one strip for 10 seconds at f/5.6; another for 10 seconds at f/8; another for 10 seconds at f/11; and a final one for 10 seconds at f/16. By keeping the time consistent, you will have little problem with reciprocity failure. You then process and dry the print according to directions.

The next step is to evaluate the test print. The light you use for viewing should be of the same quality as the light under which the final print is to be displayed. Judge the best exposure area for color balance. (If all temperature controlled sink. By using this method you can handle the prints by putting them into individual hangers or specially designed baskets. Normally when using the tank method you can employ nitrogen burst agitation which is more consistent than hand agitation.

In addition to air drying, you can use the newly designed dryers that are made to handle resin coated paper.

Another point to keep in mind is that a color print should only be judged after it has dried. This is because there is a blue cast to the print until the stabilizer has dried.

You should also keep in mind that you can use a Wratten 10 safelight (dark amber) during the exposure and processing of Ekatocolor paper. The use of a safelight will help you in handling of materials.

Exercise (649):

1. Outline and explain the three basic steps in the Ektaprint 3 process.

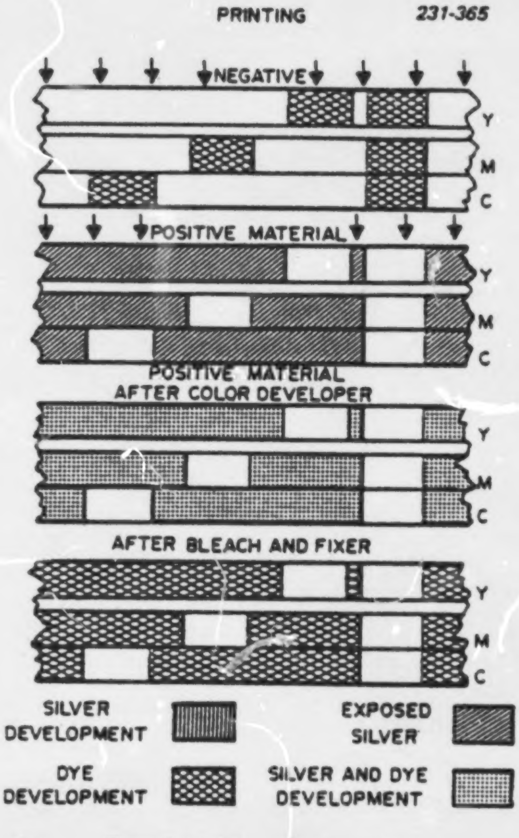

Figure 5-16. Color print processing.

650. Complete statements on printing color negatives on Panalure paper.

Panalure Paper. In order to give balanced monochromatic tonal rendition, a black-and-white print paper to be used for printing from color negatives requires an emulsion sensitive to all colors. Kodak Panalure paper has such a panchromatic emulsion. Prints made on Panalure have excellent rendition when compared with prints made on Kodabromide or Polycontrast type papers. Prints made on these latter two papers will result in the red areas looking unnaturally dark and the blues unnaturally light.

When exposing Panalure paper you can first make your test strip just as you would in regular black-and-white printing. Average times run around 5 to 10 seconds. You may use a Wratten 10 safelight just like when you are color printing. Dodging and burning in can be accomplished with the use of appropriate color compensating filters. To lighten a color, use a filter of the color similar to that of the object in the scene. To darken, use a complementary color filter.

Panalure is available in both glossy single weight and fine-grained lustre, double weight (for portraits). Panalure adds an extra dimension that should always be considered and gives added reason to use color negative film for many jobs as the requestor can receive both color and black-and-white prints.

Processing Panalure Paper. You may develop Panalure in D-72, Dektol, Selectol, or Selectol-Soft developers. Use Selectol when lower contrast is desired. Selectol-Soft lowers contrast still further. You can vary the contrast approximately one full grade from the papers grade 2, by the developer selected, the dilution, and processing times. (You do not control contrast by filters as you would with Polycontrast paper.) The following chart indicates the variations possible for developing Panalure.

Developer	*Dilution*	*Processing Time in Minutes*
D-27	1:2	1 to 3
Dektol	1:2	1 to 3
Selectol	1:1	2
Selectol-Soft	1:1	2

After the development step, you will rinse, fix, wash, and dry the prints exactly as you would any other prints on black-and-white paper.

Exercise (650):

1. Complete the following statements on using Panalure paper.
   a. Panalure paper has a ________________ emulsion.
   b. You can use a ________ ________ safelight when printing with Panalure.

of your exposures are way off then you should make another test.) You must now decide what color is excessive and how excessive that color is. First of all, make a guess as to which color should be subdued. Then view the print with a 0.05 density filter of a complementary color. (Viewing filters are made by Kodak and other photographic suppliers. They come in the six basic colors and in a variety of densities. The filter sets come with instructions on how they are to be used.) If that improves the rendition of the print, you can then change your filter pack accordingly. If not, by viewing the print through different colored filters of varying densities, you can get a good idea of what color(s) is/are out of balance. In this regard, consider table 5-6, using the following as a basis for evaluation:

- Very slight—only a tinge of the color in excess.
- Slight—more definite excess of the color.
- Considerable—weakens other colors.
- Great—overpowers other colors.

Once you have decided on a new filter pack you make another print. This print is then evaluated and further changes in the pack or exposure are made until the proper print is made. Color balance should be within 0.05 for best results.

NOTE: With certain negatives it is impossible to get all the colors to be correct. This is particularly true when complementary colors are both off. When this is the case, make sure the most important color comes out right. For example, in portrait work the facial tones are very important. You can also dodge and burn the paint using color compensating filters. To lighten a color, use a filter of the same color; to darken, use a complementary color.

The trial and error method is slow and uses up a great deal of materials. Yet this method is the basis for all color exposure methods. As you advance in your training you will learn how to use a densitometer (called off-easel evaluation) and a color analyzer (on-easel evaluation) to determine exposure and color packs. These two methods, however, require that you have established basic color packs from a standard negative which is similar in quality to the negative you are attempting to print. The basic color packs for any standard negative are established by trial and error. So by mastering trial and error you will find the other two methods simple to learn.

NOTE: Without going into great detail, let us say that a standard negative is a test negative shot under a given set of conditions. Normally a test negative is shot using the lab's portrait setup, another under daylight conditions, and a third using tungsten film in a copy setup. You can make as many standard negatives as you want using different types of color films and lighting. Each test shot normally includes a gray card and a color chart to provide a standard reference. You then establish what makes a good print using each of these negatives. Negatives exposed under a similar condition then can be compared with the appropriate standard negative.

Exercises (648):

1. Explain the difference between the additive and white light method of color print exposure.

2. What is the normal starting pack for printing with Ektacolor 37 RC paper?

3. What filter is always in place when you print?

4. What filter pack changes (refer to table 5-6) would you make if your print was
   a. very slightly blue?
   b. much too red?
   c. slightly yellow?
   d. very slightly cyan?
   e. considerable green?

649. Outline and explain each step in color print processing.

Processing Color Prints. Processing color print paper is similar to processing color negative film. The basic steps of development, bleach, and fixing are reviewed in figure 5-16. To be more specific, let us illustrate how Ektacolor 37 RC paper is processed in the new Ektaprint 3 chemistry. The specific times for each step will depend on the method of processing. This is because different methods provide different rates of agitation. The effect of each step on the paper is the same as the effect on color film.

NOTE: As has been said many times before, you must consult your appropriate data sheet for the paper/chemistry/processing method that you are using.

Tray Processing	*Time**	*Temperature*
a. Developer	3 1/2 minutes	88°F
b. Bleach-fix	1 1/2 minutes	88°F
Remaining steps can be done in normal room light.		
c. Wash	2 minutes	88°F
d. Stabilizer	2 minutes	88°F
e. Air dry		

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*Include a 20-second drain time in each processing step.

NOTE: Between the developer and the bleach-fix, you can add a C-22 stop bath step (1 minute at 88°F) and a wash (1 minute at 88°F). These two steps help prevent streaks and excessive carryover of developer to the bleach-fix.

If you process by tray, it is a good idea to wear gloves because the color chemistry is toxic. Better than tray processing is using tanks which are placed into a

c. When using Kodabromide to print color negatives, the blues of the subject will print too __________ and the reds will be too ________ .

d. Panalure's contrast is controlled by ________ rather than using filters.

e. Very low contrast development can be achieved by using __________ .

5-8. Color Printing Filters

As explained in the previous section, filter pack determination is vital in color printing. To emphasize this point, we will discuss the use of color printing filters.

651. Complete statements regarding the description and application of color printing filters.

Printing Filters. First, you should know that Kodak (for example) makes two types of filters for color printing purposes:

a. Color-compensating (CC) filters are made of gelatin and are optically perfect to the extent that you may use them in the path of the image-forming light, if necessary, either between the negative and lens or below the lens. Color compensating filters are supplied in all six colors in a range of densities running from 0.05 through 0.50. (Density is measured in terms of the wavelength of maximum absorption. For example, the density of a cyan filter is in terms of the amount of red light it absorbs. Normally, you will want to use the minimum number of filters that are necessary.)

b. Color printing (CP) filters are made of acetate and are designed only for use between the negative and the light source. Color printing filters are not recommended for use in the path of image-forming light, since a loss of image sharpness and quality may result. CP filters are less expensive than CC filters and are available in yellow, magenta, cyan, and red in densities from 0.05 through 0.40.

NOTE: Most modern color projection printers use color printing filters located in a specially designed head. These filters are quite durable and of very good quality. Nevertheless, filters of any type must be routinely checked for scratches, dirt or fade, and should be replaced as required.

Filter Packs. The combination of filters to be placed in the exposing light beam should always be the simplest one possible. This better insures the sharpest possible image, the fastest printing times, and the elimination of neutral density. Neutral density is created when any two or all three additive primaries or all three subtractive primaries appear in the filter pack.

You can simplify the determination of filter combinations by thinking of all filters in terms of the subtractive colors (cyan, magenta, and yellow). Red is a combination of yellow and magenta; green is a combination of yellow and cyan; and blue is a combination of magenta and cyan. (Just like the color star!) You can use the following operations when working with the subtractive color filters:

1. If you are given values in the additive colors, they may be converted directly into the subtractive colors. For example, 20R = 20M + 20Y.

2. Values can be added or subtracted in normal arithmetic fashion. For example, 20M + 10M = 30M.

3. If the resulting filter combination contains all three subtractive colors, take out the neutral density by removing an equal amount of each color to bring cyan down to 0. For example, 20C + 30M + 50Y = OC + 10M + 30Y.

NOTE: Changes in filter packs will change the amount of your exposure. Charts supplied with the filters you are using will give you a number by which you can compute your new exposure with a change in filtration.

Use of Filters In Dodging and Burning-In. CC filters may be used to change the color balance in a local area of a print. To lighten a color you would use a color filter of the same color. For example, to lighten a blue shadow you would use a blue filter. To darken a color, you would use a complementary color. Remember to keep your filter moving during the exposure to prevent the formation of a line.

Exercise (651):

1. Complete the following statements on the use of filters for color printing.
   a. Color compensating filters are made of ______ and are __________ perfect.

   b. A 0.10 yellow filter absorbs 0.10 of ________ light.

   c. __________ __________ filters are made of acetate and are designed to be used between the negative and the light source.

   d. 30B is the same as __________ __________ and __________ __________ .

e. A highlight that is too green can be lightened by dodging with a _________ filter.

5-9. Finish Color Materials

Once transparencies or prints are processed they must be "finished." In the case of transparencies, they need to be mounted. Mounting techniques will be discussed in the next section. We will now point out techniques that are applicable to color prints.

652. Complete statements on the tools and techniques of color print finishing.

Finishing Color Prints. Often it is necessary to remove or eliminate minor stains, spots, or blemishes from color prints. Two techniques are sometimes used: etching and spotting. Etching refers to the physical removal of a portion of the emulsion from the print. This technique which may remove dyes is not recommended. Spotting is the application of dye or the use of colored pencils to cover over a blemish. This method is routinely used. In addition, basic spotting techniques can be extended to larger areas to enhance the color balance of the print. Since spotting is important, we will go into some detail on the basic procedures that are involved.

Dry-Dye Technique for Large Areas. Dry dye spotting makes use of Kodak Retouching Colors (or an equivalent). Retouching colors come in red, green, blue, cyan, magenta, yellow, orange, brown, and neutral, plus a jar of reducer. Using the dry dye technique with these colors will give you these advantages: You can experiment until you achieve the desired effect without making it permanent, you can retouch glossy prints without loss of the gloss, and you can cover large areas.

Follow these techniques when using the dry dye technique:

1. The print should be clean and dry before spotting is done.
2. To use, breathe on the cake of retouching color to be used. Pick up the dye by rubbing a tuft of dry cotton over the cake. Transfer the dye to the print using a circular motion over the area.
3. To remove unwanted dye, breathe on a cake of reducer and pick up a sufficient amount on a tuft of cotton and clean off the unwanted dye. The area should be buffed to achieve proper blending. Finally a tuft of clean cotton should be used to buff away any reducer.
4. To make the dye permanent, subject the retouched area to steam for 5 to 10 seconds. Dye density can be increased by repeating the process of applying dye and steaming it.
5. To remove steam set colors, use undiluted Kodak Photo-Flo 200 Solution. The solution is applied and then within a minute it is completely swabbed off with fresh clean cotton that has been moistened with a 1:1 solution of water and Ektaprint 3 Stabilizer.

Wet-Brush Technique. The wet-brush technique uses the same Kodak Retouching Colors to spot very small areas. Use the following techniques to put the wet-brush method to work.

1. Moisten the dye with a solution containing equal parts of water with Ektaprint 3 Stabilizer.
2. Using a spotting brush, mix the desired dye or dyes in a palette cup (or use a sheet of glass).
3. Add a touch of neutral color to the dye mixture to reduce the brilliance of the pure color.
4. Remove excess dye from the brush onto blotting paper.
5. Spot-in the area, making sure that the dye is kept within the confines of the spot.
6. If too much dye has been added, blot the area immediately with blotting paper.

Black Spots. Black spots caused by pinholes can be corrected by applying white opaque to the spot. After the opaque dries you can then spot with colored pencils.

Off-Color Areas. To correct an off-color area, using either the dry-dye or wet-brush technique, use the following colors:

To Correct	*Use*
Red	Cyan
Green	Magenta
Blue	Orange
Purple	Yellow

NOTE: Notice that because you are working with pigment colors rather than colors of light the relationship between colors is different..

Preserving and Texturing. By now you have spent several hours of work in producing a top quality finished print. If the prints are to be continuously displayed or subjected to unusual or intermittent storage, they deserve to be protected by a coating of lacquer. Lacquer does not guarantee protection against deterioration, but it does prolong the useful life of the print. Additionally, you may use lacquer and lacquer-type products to obtain various texture finishes. A few of the proven protective coatings are Getzel Type C Matte Lacquer, Marshall Pre-Color Spray, Flexichrome Print Lacquer, Pro-Texture, and Pro-Tecta-Cote. Most lacquers can be applied directly to the print surface with a brush, but some are sold in pressurized spray cans.

A variety of textures ranging from satin to brushed-oil can be obtained with the Pro-Texture preparations. These finishes, however, require spray-paint apparatus. A simpler method for texturing color prints is to emboss a texture on the print surface with an embossing screen, a variety of which are commercially available.

Mounting Color Prints. You can dry mount finished color prints by the usual means used for black-and-white prints if the temperature of the press does not exceed 230° F. They can also be satisfactorily mounted with Kodak rapid mounting cement. You should not use rubber cement or paste containing water (or penetrating solvents).

Exercise (652):

1. Complete statements on the tools and techniques of color print finishing.
   a. ______ is not a recommended method for correcting print blemishes.
   b. Dry dye is used to cover a ______ area.
   c. To remove dry dye you normally use ______.
   d. To make dry dyes permanent, you use ______.
   e. Photo-Flo is used to remove dry dye color that has been ________.
   f. The wet brush technique is used to cover a ______ area.
   g. Black spots on a print are caused by _______.
   h. To correct an off-color blue area, you would use ______ dye.
   i. When mounting a color print, you should not use a mounting temperature above _______.

5-10. Slide Mounting

There are many methods of mounting slides, each with certain advantages and disadvantages. Slides may, for example, be mounted in cardboard, glass, plastic, and combinations of these materials. We will go over the basic types plus the use of a slide mounter.

653. Complete statements on the mounting of slides.

Tape and Glass. Some of the first film clips to be mounted as slides were mounted between two pieces of glass taped on the edges to hold the sandwich together. This is the most time consuming and costly way to mount slides; however, so durable is this method that it is still practiced today, especially in larger lantern slides. When properly assembled, this type of slide will, survive an amazing amount of abuse short of glass breakage. Recently waterproof tapes have been developed which makes it possible to remove almost any type of surface contaminants this slide may encounter.

Metal With Glass. This type of mounting provides a high degree of protection and is generally less time consuming to assemble than tape and glass. Some mountings of this type are thicker than standard slide trays and may tend to jam or stick in automatic slide changers. Manufacturers of automatic changers have realized this fact and several have redesigned their equipment to accommodate this popular method of slide preparation.

Plastic With Glass. This is the most popular glass mounted slide. It has the best features of the metal and glass type but costs less and is thinner. Some have less impact resistance than metal slides; and as is the case with all glass mounted slides, the tendency to form Newton Rings is present.

Newton Rings. These are optical interference patterns that result when humidity causes a very slight irregular separation between two or more optically flat plane parallel surfaces. The pattern appears as a variable area of color similar to that seen on an oil slick or in a soap bubble. To eliminate this troublesome occurrence, the optical flats must be separated. This can be accomplished at great time loss by scrubbing the glass surface with scouring powder or at least time loss by dusting the film or glass with offset powder. When employing the offset powder technique, it is important to use a non-toxic, non-abrasive, inert powder, and a light touch. Stop Offset Spray Powder Grade No. 3 has proven to be very effective for this purpose. The light touch is a matter of practicing the following technique. Dip a No. 1 artist's brush in the powder, shake excess off; then holding the tip of the brush about 6 inches above the glass and transparency matting surface, snap the brush sharply with the thumb and forefinger much as you would in shooting marbles. Practice makes perfect! Too much powder and the illustration becomes noticeably speckled. Too little and there are still Newton Rings.

Cleaning Glass. Another problem common to all glass mounting systems is cleaning the glass. This is time consuming and generally involves considerable hand labor. Glass washing machines have been devised but have not proven to be completely successful. The most dependable approach is to soak and wash glass in a cleansing solution, followed by clear water rinse.

You then dry with dust-free circulating air or lint-and-wax-free wiping towels. Various agents may be used in compounding the cleansing solution. Detergents of the type recommended for automatic dishwashers, ammonia with water, alcohol with water, and solutions of tri-sodium phosphate are excellent. Less desirable are glass cleaners containing wax and detergents with high wax content. Such cleaners impart a gloss that is very susceptible to abrasions when contacted with wiping towels. Abrasions of this type serve as dust collectors and impair the quality of the projected image.

Glassless Mounts. Mounts made of plastic or cardboard are by far the most popular method of mounting 35-mm slides. They offer advantages such as lower cost, maximum adaptability to projection equipment, no glass breakage, no Newton Ring problems, and easier mounting. The principal disadvantage is the loss of some protection. The side surfaces of the film are susceptible to fingermarks and abrasions when given rough treatment. Under normal circumstances, where the entire slide set is protected in storage boxes or trays, the risk of surface damage is small. Because the advantages outweigh the disadvantages, this has become the number one way to mount slides. Mounts of this type are supplied in several forms. Some typical constructions are as follows:

1. Hinged Type—Where the film clip is positioned in the center of the open mount, the top or hinged flap is brought down over the transparency and the three sides sealed.
2. Two Part—Here the film clip is positioned on the bottom part, a top is placed over the transparency and sealed on all four sides.
3. Insert Type—The mount is presealed on three sides where manufactured. The transparency is cut to size and inserted into slot on unsealed side of mount, which is then sealed.

The Slide Mounting Press. The hand mounting methods that have been described are too slow for the heavy production schedules found in a majority of Air Force labs. Automatic and semi-automatic machines are available to ease the load.

The "Seary" Slide Mounting Press, shown in figure 5-17, is a semi-automatic, electrically operated sealer and press. Assembled slides are fed into the slide mounting slot in the platen at the top of the press. The press closes automatically, heats and seals the slide mount during a short, electrically timed interval, then opens for the next slide. Finished slides drop down a chute to form a neat stack. Closing, pressure control timing, stacking, and heat controls are automatic. The operator, however, must have cut each individual slide from the roll and placed it into the cardboard mount.

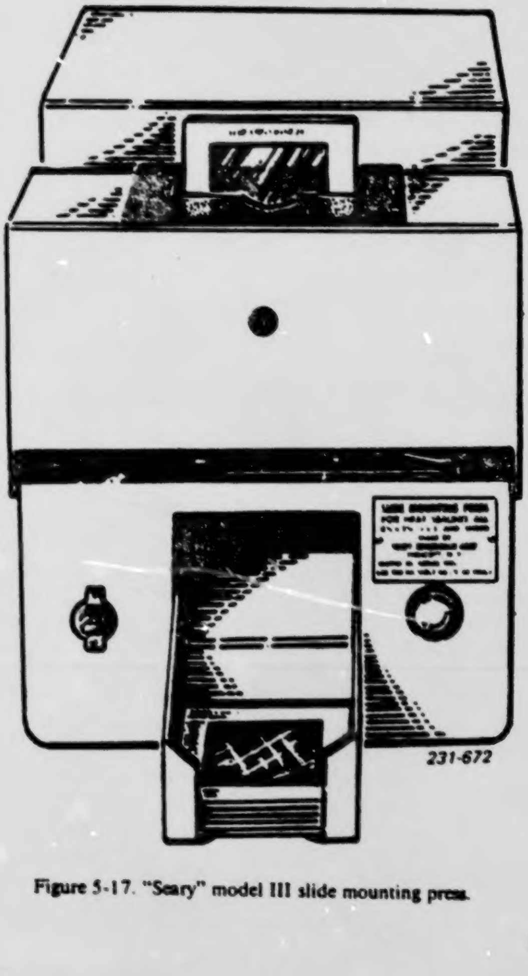


Figure 5-17. "Seary" model III slide mounting press.

Exercise (653):

1. Complete the following statements on the mounting of slides.
   a. The most durable slide mount is made with a combination of ______ and __________.
   b. All glass mounts may suffer from __________ __________.
   c. When cleaning glass for slide mounts, you should not use a cleaner that has a high ______ content.
   d. A ________ ________ is essential for high production slide mounting operations.

Photographic Quality Control

QUALITY CONTROL has one purpose—the betterment of the end product. Quality control can be applied to a portion of the system or to the entire system. In this chapter we emphasize the quality control checks you can perform on your photographic chemistry. Applying the tools of chemical analysis and sensitometry can better insure that you obtain consistent quality results. Although we emphasize black-and-white chemistry, the same principles apply to your color work.

6-1. Observing Laboratory Cleanliness

Quality control begins with laboratory cleanliness. If you feel that laboratory cleanliness is not important, ask yourself whether or not you would want a doctor to operate on you with a dirty scalpel, whether you would want a service station attendant to put into your automobile gasoline that was full of dirt, or whether you would want a furniture repairman to polish a fine piece of your furniture with a greasy polishing rag. Of course you wouldn't. Neither would you want to work in a dirty laboratory. All the care you may employ in processing is totally wasted if your solutions are contaminated with foreign particles which adhere to the surface of the film. What good is film if it has a full-length scratch caused by a chemical deposit on a processor roller? The purpose of laboratory cleanliness is to prevent a loss of quality from conditions in the laboratory.

654. State principles and techniques of laboratory cleanliness.

If any degree of quality control is to be maintained, regular laboratory cleanup is a must. The cleanup should involve far more than just sweeping the floor. The entire floor area should be mopped—once with hot, soapy water; again with clear clean water; and then a third time with a dry mop to remove any water left on the floor. Check all corners or any other places where dirt may collect.

You can be sure that if there is dirt on the floor, there will be dirt and dust in the air. Airborne dirt and dust somehow find their way to the surface of your film and cause defects. With this in mind, make it a special point to clean any area where dirt or dust may collect. Wipe ledges, window sills, etc., with a clean, damp sponge. Rinse your sponge frequently, since a dirty sponge deposits residue that, when dry, becomes airborne again.

Processing machines, printers, and any other equipment should be wiped down daily to prevent accumulation of dust or chemicals. When cleaning the equipment, pay particular attention to any point where the film may come in contact with any abrasive type of material. Rollers should be cleaned to prevent chemical buildup which can scratch or, in extreme cases, tear film.

Film loading rooms should be kept as clean as possible to prevent foreign matter from becoming imbedded in the film before shooting or processing.

You can greatly increase laboratory cleanliness by being careful in your day-to-day duties. Be careful not to spill chemicals on the equipment or on yourself. If you should spill chemicals, clean them as soon as possible to prevent their being carried to other portions of the lab. If spilled chemicals are left to dry on the floor, they revert to their original powdery form. As you walk back and forth, you stir these chemicals, they become airborne, and eventually fall back and cover all flat places.

When you have done as much as you can to maintain the cleanliness of a laboratory, you are on the right road to good quality control. Even so, chemicals, dust, and lint can still be a problem. Therefore, you must employ visual examination as a check on cleanliness.

Exercises (654):

1. How should a floor be mopped to insure proper cleanliness?

2. Why should you pay particular attention to processing machine rollers?

3. Why should you clean spills as they occur?

6-2. Handling and Securing Chemicals and Solutions

Chemicals and solutions must be properly stored to insure proper keeping and safety. In this section we briefly discuss the handling and storage of chemicals.

655. Complete statements on the proper handling and storage of chemicals and solutions.

Most chemicals deteriorate if they are exposed to air, moisture, or excessive heat. Therefore, you should store bulk or packaged chemicals in a cool, dry room. In addition, the chemicals should be stored in a section that is removed from the sensitized materials.

Certain chemicals, such as mercuric chloride, are highly poisonous and should be in a locked cabinet. Each chemical should be clearly labeled. When certain chemicals are stored together, there is a danger that through breakage they may be mixed. For example, a combination of sulfuric acid and potassium ferrocyanide can produce lethal cyanide gas. Such chemicals should be stored on a lower shelf to reduce the chance of breakage.

Handling and storing processing solutions present numerous problems, most of which are directly attributable to the chemicals they contain. For example, most stock developer solutions have good keeping qualities when stored in tightly corked bottles. A partly filled jug, however, contains a good deal of air, which causes the developer to oxidize. Hence, it is a better practice to store stock solutions in several small jugs rather than in one large one. The entire contents of one jug can be used, leaving the remaining jugs for future use.

Developers stored in tanks should be covered by a floating lid made either of wood or plastic. After removing the lid, the surface of the developer should be skimmed with a clean blotter to remove any crust before the developer is used.

Fixing baths generally have excellent keeping qualities, and you may store them in large tanks provided with covers to keep out dust and dirt. On the other hand, you must store the acid solutions used for stop baths or bleaches in tightly stoppered, acid-resistant containers. Whenever possible, when storing acid solutions, use glass or crockery jugs with rubber or glass stoppers. These containers and stoppers have been proven best for this purpose. Like toxic chemicals, acids are best stored on the lower shelf of the storage cabinet or on the floor. One final reminder—be sure that all of your mixed solutions, like your bulk or packaged chemicals, are clearly and properly labeled.

Remember the need for proper handling procedures. Chemical mix personnel should wear rubber gloves, aprons, and face masks when handling chemicals for storage as well as mixing. Since many chemicals can cause irritation to the skin or nasal passages, all photographic workers should keep chemical safety constantly in mind.

Exercise (655):

1. Complete the following statements on the handling and securing of chemicals.
   a. Chemicals deteriorate when exposed to __________, __________, and __________.

   b. A combination of sulfuric acid and potassium ferro-cyanide produces ______ ______.

   c. Air will cause a solution to __________.

   d. Acids are best stored close to the __________.

   e. __________ safety should always be observed by photographic workers.

6-3. Employ Visual Evaluation

While it is not truly scientific, visual examination can greatly improve the quality of your work. By checking your negatives, slides and prints for proper density, contrast, and absence of defects, you can identify what you are doing right and where your problems are coming from. Remember, if you can't look at your own work and take pride in it, you can't expect the requestor to think much of it either.

656. Given a list of print or negative defects, identify the cause of each one.

Visual Examination. The key to visual examination is to have an appropriate check list and a consistent viewing standard. For example, you may develop a list that covers density, contrast, sharpness, and mechanical (pinholes, scratches, etc.) and chemical (stains, etc.) defects. You then follow a consistent viewing pattern. You should always look at your negatives, slides, or prints, using the same light table or viewing light, etc. Only in this way can you have a consistent basis for making a judgment.

NOTE: In this regard it is a good idea to use a photo lamp to magnify your negatives and slides to spot defects that will show up in printing or in projection.

What to Look For. First you should look at the density of the product. Too much exposure produces negatives that are too dense, prints that are muddy, and slides that are thin. Too little exposure leads to thin negatives and prints and saturated slides. How about the contrast? There should be detail in both the highlights and shadows unless you are going for a special effect. Negative contrast is a product of development, so if your negatives are too contrasty you might need to cut your development time. If they are too thin, you must increase the development time. The contrast of prints can be altered through choice of paper grade, filter, or, to a limited degree, development. Slides, unfortunately, can only be corrected by copying, which normally results in a product that is slightly inferior to the original. Sharpness is a product primarily of your focusing. It is too late if your negatives or slides are off. If you have a soft print, you can reprint. Consistently soft results should cause you to check your equipment or your technique! Finally, there are innumerable mechanical or chemical defects caused by defective cameras, accessories, improper handling, or contaminated chemicals. The following are a sampling of what you might encounter:

a. The image appears hazy and lacking in contrast.

(1) The sun was shining into the lens. Remember, it is necessary to protect the lens from the direct rays of the sun when you take a photograph against the light. Light striking the lens causes a hazy, indistinct image. Sometimes, bright light striking the lens produces large circles which partially obscure the image.

(2) Your lens is dirty. Many times, dust or condensed water vapor on the lens results in hazy pictures. Remember to clean your camera lenses frequently.

(3) Overexposure.

(4) The negative is fogged.

b. You observe small transparent and irregularly shaped spots. This is often caused by dust settling on the film before the exposure. It can be corrected by cleaning the camera interior and by loading the film in a clean environment.

c. Small circular transparent spots or air bells—these are produced by small air bubbles on the surface of the film during development. This problem can be taken care of by proper agitation.

d. When a negative emulsion has a wrinkled appearance (reticulation)—this is produced by an abrupt or sudden swelling or contraction of the film. Sharp differences in the temperatures of successive processing solutions and/or insufficient hardening of the gelatin are the usual causes of reticulation.

e. The image is not sharp.

(1) The subject moved. If this is the case, any stationary objects included in the picture will be sharp, assuming that they are in focus. Lack of sharpness will be confined to the parts that were in motion at the time of exposure.

(2) The camera moved. If this is the case, there is a general blurring of the image. Sometimes, you will observe double lines made by the subject. Remember that the average photographer cannot hold the camera perfectly still for an exposure longer than 1/30 second.

(3) The subject is not in focus. If other parts or objects of your negative are sharply defined, while objects at other distances are not sharp, the camera was not set for the proper distance. You made an error in using the rangefinder, focusing on the ground glass, or selecting the correct distance on the distance scale.

f. Dense areas of varying width along the edge of the negative—this condition is produced on roll film when the film is not tightly wound upon loading or removal from the camera.

g. The image on your negative is partially a positive. This is due to reversal of the image and is sometimes caused by hypo in the developer. More often, it is the result of a brief exposure to light during development.

h. A yellow stain appearing after the negative is dry—this may be caused by insufficient fixation or the use of an exhausted fixing bath and discolor upon exposure to light. Small yellow or brownish spots are due to air bubbles on the film during fixing.

i. Pink stains are due to traces of the dye applied to the back of certain films for the purpose of preventing halation. The stains can often be removed by placing the film in a 5-percent solution of sodium sulfite after washing. The film should then be returned to the wash for an additional 5 or 10 minutes. If the negative is dry, it should be allowed to soak in water for 10 to 15 minutes before being placed in the sodium sulfite solution.

j. Blisters or circular pits in the emulsion when viewed from the surface—the blisters may be produced by concentrated developing solutions, developer or fixing solutions which are too warm, insufficient rinsing between developing and fixing, or an old or incorrectly compounded solution.

k. Grayish whites over the entire print are usually caused by chemicals or light fog. They also may be caused by insufficient potassium bromide in the developer, too long a development time, or the use of outdated paper.

l. A grayish-mottled or granulated appearance of the edges or entire print is usually caused by underexposure and forced development. This effect may also be caused by using outdated paper. Moisture within the paper or exposure to chemical fumes, such as ammonia, can also produce this effect.

m. A purple discoloration of the print is caused by lack of agitation in an acid stop bath.

n. White deposits over the entire surface of a print are caused by milky hypo baths and incorrectly mixed or impure chemicals.

NOTE: The above is not an inclusive list of negative and print defects. Most manufacturer's of photographic materials and chemicals have charts listing defects and their causes. Such lists are very helpful as you strive to produce top quality work.

Exercise (656):

1. Identify the cause of the following defects.
   a. Thin slides.

   b. Muddy prints.

   c. Hazy negatives.

   d. Negative has wrinkled appearance.

   e. Negative is partially positive.

   f. Small yellow or brownish spots on the film.

   g. Grayish whites on your print.

   h. Purple discoloration to the print.

6-4. pH Content

Determination of pH indicates the acidity, neutrality or alkalinity of a solution. The pH strength of a solution is an indication of its strength and consequently its activity. Different photographic solutions are designed to operate best at a certain range of pH values. By measuring the pH of the solution you can assure that your chemistry will perform properly.

657. Definition of pH.

What is pH? The pH value is the logarithm of the reciprocal of the hydrogen ion (H^+) concentration in a solution. The value of the pH of a given solution, expressed in mathematical form, is as follows:

$$pH = -\log_{10} (H^+)$$

On a pH scale the values run from 0 to 14. 7 represents the pH of pure water. Values greater than 7 indicate the degree of alkalinity. The numbers less than 7 indicate an acid. The relative strength of acids and alkalies changes ten times for each unit change in pH. Thus, compared with a solution of 6, a solution 5 is ten times stronger, solution of pH 4 is a hundred times as strong, and a pH 3 would be a thousand times stronger than a pH of 6.

Exercise (657):

1. Define pH in terms of mathematics and in terms of the pH scale.

658. Explain the importance of pH in determining the quality of different photographic solutions.

Why pH Is important. To learn the importance of pH in photographic solutions, you must know how pH affects each of the individual solutions involved in the photographic process. So now let's go into pH as it applies to different photographic solutions.

Developer pH. The range of pH for practical development varies with the nature of each individual developing agent used in each developing solution. Organic developing agents, in general, do not function at a practical rate of speed unless they are in an alkaline solution. However, a few organic agents—for example, Amidol—differ from the average organic agents and can develop at a reasonable rate even in a slightly acid solution. Certain other developing agents function over a wide range of pH values. The manufacturer supplies data as to the best pH strength for proper use. This value may vary with different rates of dilution. The point to remember is that if the developer is too strong, it may cause damage to the film or too much contrast if you process at your normal times. Conversely, if the solution strength is too weak, you will not have adequate contrast. By knowing the pH of your solution you can predict the degree of development you will be getting.

Fixing bath pH. The time that elapses before the fixing bath begins to deteriorate depends largely upon the pH of the fixing bath. In practice, the thiosulfate fixing bath with potassium alum as a hardening agent is normally used at a pH above 4 and below 6. However, when chrome alum is used as the hardening agent, the pH is usually held to a range of from about 3 to 4.

Potassium alum is normally used as the hardening agent in fixing baths. The hardening produced is dependent not only upon the concentration of the potassium alum but also upon the pH of the solution. Starting at a pH value of about 3.5 and working upward, the hardening action increases. Hardening action reaches its peak at a pH value of about 5.0. Beyond this peak, the action decreases very rapidly until it becomes almost negligible at a pH value of about 6.0. Little, if any, hardening action takes place when the solution becomes neutral or alkaline.

Many factors must be considered when you want to

TABLE 6-1
"T" IS THE TRANSITION OR ENDPOINT

pH INDICATORS 231-702

pH	1 2 3 4 5 6 7 8 9 10 11 12 13 14	Preparation
Methnil Yellow	- R-T --------------------- Yellow ----------------------	.01 % in water
Methyl Violet	- Y. G. B. -T -------------- Violet -----------------------	.01 %- .05 % in water
Methyl Orange	-Pink. Red- T ------------- Orange -----------------------	.01-% in water
M. E. P. (E. O. X.)	- Green -- T ------------ Violet -----------------------	ready to use
Bromcresol Green	--- Green ----- T ---------- Yellow ----------------------	ready to use
Alizarin	--- Yellow ----Ⓣ--------- Red ------------ T -Purple --	.01 % in water
Litmus	--------- Red ---------- T ----------Blue ------------------	in paper form
Phenolphthalein	------------Colorless ---------- T --------- Red -----------	.05 g in 50cc alcohol / 50cc water
Alizarin	--- Yellow ---- T ---------- Red ------------Ⓣ Purple --	.01 % in water
Clayton Yellow	----------------- Yellow --------------------- T - Amber -	.01 % in water

determine the correct pH of the fixing bath. If the pH is decreased to any extent beyond the optimum limit for ideal hardening, there is a great possibility of emulsion damage. In addition, the low pH makes the task of washing the fixing byproducts out of the emulsion more difficult. Yet, if the pH is too high, the emulsion is subject to damage and staining, and the hardening agents tend to sludge out of the fixing solution.

Carryover of developer into the fixing bath tends to increase the alkalinity of the fixing bath as it is being used; thus, there is a tendency for a rise in the pH. Normally, however, the fixing solution is buffered against this increase in pH by acetic acid, sodium bisulfite, and/or boric acid that is contained in the fixing bath formula.

Wash water pH. The rate of washing depends, to some extent, upon the pH of the wash water as well as upon the composition and the pH of the fixing bath. A pH slightly above 7 tends to increase the rate of washing. When you are washing film, which has been adequately fixed and partially washed, treatment of the film with a 0.03 to 0.3 percent solution of ammonia for a few minutes appreciable decreases the subsequent washing time. The same result is sometimes achieved by continuous, controlled addition of ammonia to the wash water.

Exercises (658):

1. Why must the pH of a developer meet established standards for a good result?

2. What effect does the pH of a fixing bath have on the hardening qualities of a fixing bath?

3. A slight increase in the pH of your wash water will have what result?

659. State principles and techniques in determining pH.

Determining pH. The preferred pH for a given solution is determined from such guidelines as have been previously expressed, as well as by the careful analysis of the photographic solutions and of the photographic product which is made under variations of pH. The pH of a given solution becomes a standard to test the adequacy of a solution prior to use.

Methods of Determining pH. There are two common methods of determining the pH of a solution: (1) through the use of various pH indicators, and (2) the use of a pH meter. We will discuss the use of indicators presently and the operation of a pH meter in the next section.

Using the Common Indicators. The common indicators change color under different levels of solution pH. Table 6-1 shows some of the common indicators. These indicators will tell you specific pH values, but none of the indicators by themselves can indicate values over the entire range. Only one of those shown in table 1—Alizarin—goes through two widely separated transition points. If the proximity of the pH is known, the use of one or two indicators will closely pinpoint the pH; but if the approximate pH is not known, it is necessary to use various indicators until the approximate pH value is isolated by a transition.

It will be easier for you to understand the various pH indicators if we consider just two specific examples: litmus paper and the solution, phenolphthalein.

Notice, in table 6-1, that litmus paper has a transition point (or end point) shown by the letter T at a pH of 7. Litmus paper comes in two colors: blue litmus, which changes to red when in an acid solution; and red litmus, which turns blue in an alkaline solution. The litmus test is not infallible, since it cannot detect acids or bases near the pH value of 7. Normally, however, litmus can be used to determine whether a solution is an acid or an alkaline.

Phenolphthalein solution is colorless in a solution having a pH of less than 9. The pH value of 9 is the transition point, or the end point. If the solution exceeds a pH of 9, the phenolphthalein solution imparts a reddish appearance to the solution. Thus, phenolphthalein indicates whether a solution is above or below a pH of 9.

Exercises (659):

1. What is the function of red and blue litmus paper?

2. What are the two transition points of Alizarin?

3. Phenolphthalein will have what color in a solution with a pH of 10?

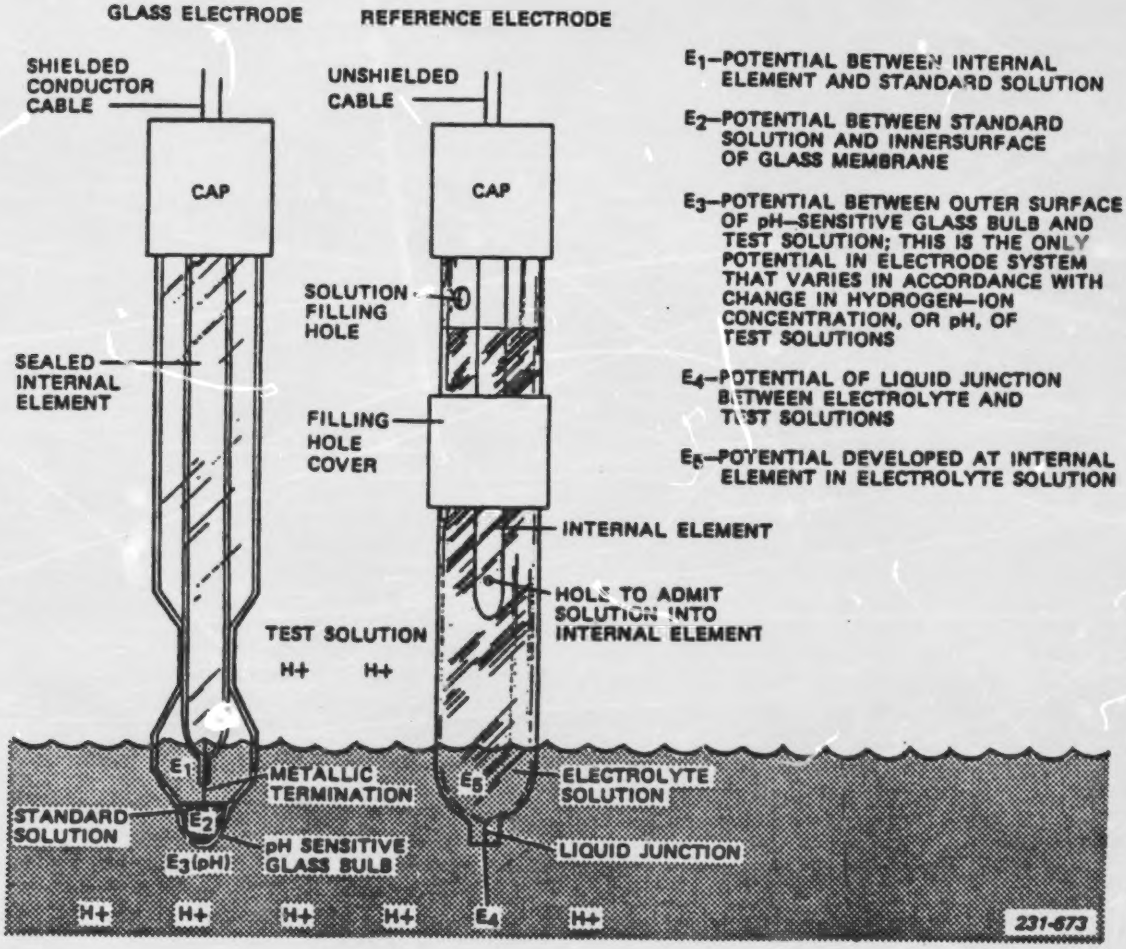

GLASS ELECTRODE
REFERENCE ELECTRODE
SHIELDED CONDUCTOR CABLE
UNSHIELDED CABLE
CAP
CAP
SOLUTION FILLING HOLE
SEALED INTERNAL ELEMENT
FILLING HOLE COVER
INTERNAL ELEMENT
HOLE TO ADMIT SOLUTION INTO INTERNAL ELEMENT
TEST SOLUTION
H+ H+
E1—POTENTIAL BETWEEN INTERNAL ELEMENT AND STANDARD SOLUTION
E2—POTENTIAL BETWEEN STANDARD SOLUTION AND INNERSURFACE OF GLASS MEMBRANE
E3—POTENTIAL BETWEEN OUTER SURFACE OF pH—SENSITIVE GLASS BULB AND TEST SOLUTION; THIS IS THE ONLY POTENTIAL IN ELECTRODE SYSTEM THAT VARIES IN ACCORDANCE WITH CHANGE IN HYDROGEN—ION CONCENTRATION, OR pH, OF TEST SOLUTIONS
E4—POTENTIAL OF LIQUID JUNCTION BETWEEN ELECTROLYTE AND TEST SOLUTIONS
E5—POTENTIAL DEVELOPED AT INTERNAL ELEMENT IN ELECTROLYTE SOLUTION
E1
METALLIC TERMINATION
E5
ELECTROLYTE SOLUTION
STANDARD SOLUTION
E2
pH SENSITIVE GLASS BULB
E3(pH)
LIQUID JUNCTION
H+ H+ H+ H+ E4 H+
231-673

Figure 6-1. Electrode system.

4. In a solution with a pH of 2, methyl violet will turn to what color?

660. Complete statements which explain the operation of a pH meter.

pH Meters. Measurement of pH with the pH meter is accomplished by determining the potential developed by an electrical cell. This cell consists of two electrodes, a glass electrode and a reference electrode, immersed in a test solution. (Note fig. 6-1.)

Reference electrode. The purpose of the reference electrode is to provide a constant reference voltage to permit measurement of the potential at the glass electrode. The reference electrode is filled with a saturated solution of potassium chloride (KCL). The constant voltage is supplied by this KCL. A small, but constant, flow of KCL solution is maintained through a liquid junction in the tip of the reference electrode. The KCL solution forms a conductive salt bridge between the two electrodes.

Glass electrode. The basic purpose of the glass electrode is to measure the hydrogen-ion concentration of the sample. The electrical potential developed at the glass electrode is proportional to the pH of the solution. The measurement of the electrical potential, developed at the glass electrode, is accomplished with the pH meter. The potential may be read directly either in pH units or millivolts.

For other types of electrochemical-potential measurement, such as oxidation reduction, a metallic electrode is substituted for the glass electrode and the readout is in millivolts. *Do not use metal type electrodes for determining pH of developers.*

Buffer. Buffer solutions are used to standardize pH meters to known pH values. There are normally three types of buffers used with different pH values: 4, 7, and 9. The exact pH of each of these three buffers is listed on the bottle or the Temperature Compensation Table (fig. 6-2). For accuracy, always select the buffer value that would correspond closest to the pH of the solution being tested. Example: When testing developers, use buffer 9; and with fixing baths, use 4. When the test solution is unknown, use buffer 7; or a quick check with litmus paper will indicate whether it is acid or alkali. A determination with litmus paper is normally preferred.

pH – TEMPERATURE TABLE

The buffer powder in this package when dissolved in 500 ml of distilled water, will give a buffer solution (accurate to +0.01 pH) of the following:

°C	pH	°C	pH	°C	pH
0	9.46	25	9.18	60	8.96
5	9.39	30	9.14	70	8.92
10	9.33	35	9.10	80	8.88
15	9.27	40	9.07	90	8.85
20	9.22	50	9.01	95	8.83

These values based on complete thermal equilibrium of electrodes and buffer.

231-674

Figure 6-2. Temperature compensation table.

As an example of a pH meter, let us briefly discuss the operation of the Beckman Expandomatic pH meter. (See fig. 6-3.)

The Beckman Expandomatic pH Meter. The Beckman Expandomatic pH meter operates on ac power of 115 volts. The pH range of this meter is from 0 to 14 and with accuracy of .05. Pushbutton operation permits simple and rapid measurements. Electrical circuit features automatic correction of zero drift once each second.

Manual temperature compensation throughout 0 to 100° C range is made by means of a single, continuously-variable control. Automatic temperature compensation is accomplished by connecting a Beckman Thermocompensator to the terminals on the Expandomatic back panel. Either mode of temperature compensation is selected with a pushbutton. Always be sure that this pH meter is grounded.

The following are the operational procedures covering the Expandomatic.

1. Operating Controls. All of the controls regularly employed in operating the instrument are arranged on the front panel. Six of the controls are pushbutton switches that provide convenience and rapidity in measurements. These switches are mounted in pairs, with the appropriate ones linked mechanically for proper interaction. In addition to the controls on the front panel, a Thermocompensator Switch is mounted on the terminal board at the rear of the instrument. A brief functional description of each control is listed below.

a. METER ADJUSTMENT CONTROL—Sets mechanical zero of meter.

b. TEMPERATURE COMPENSATOR CONTROL—Varies circuit gain to follow change of pH-millivolt span with sample temperature.

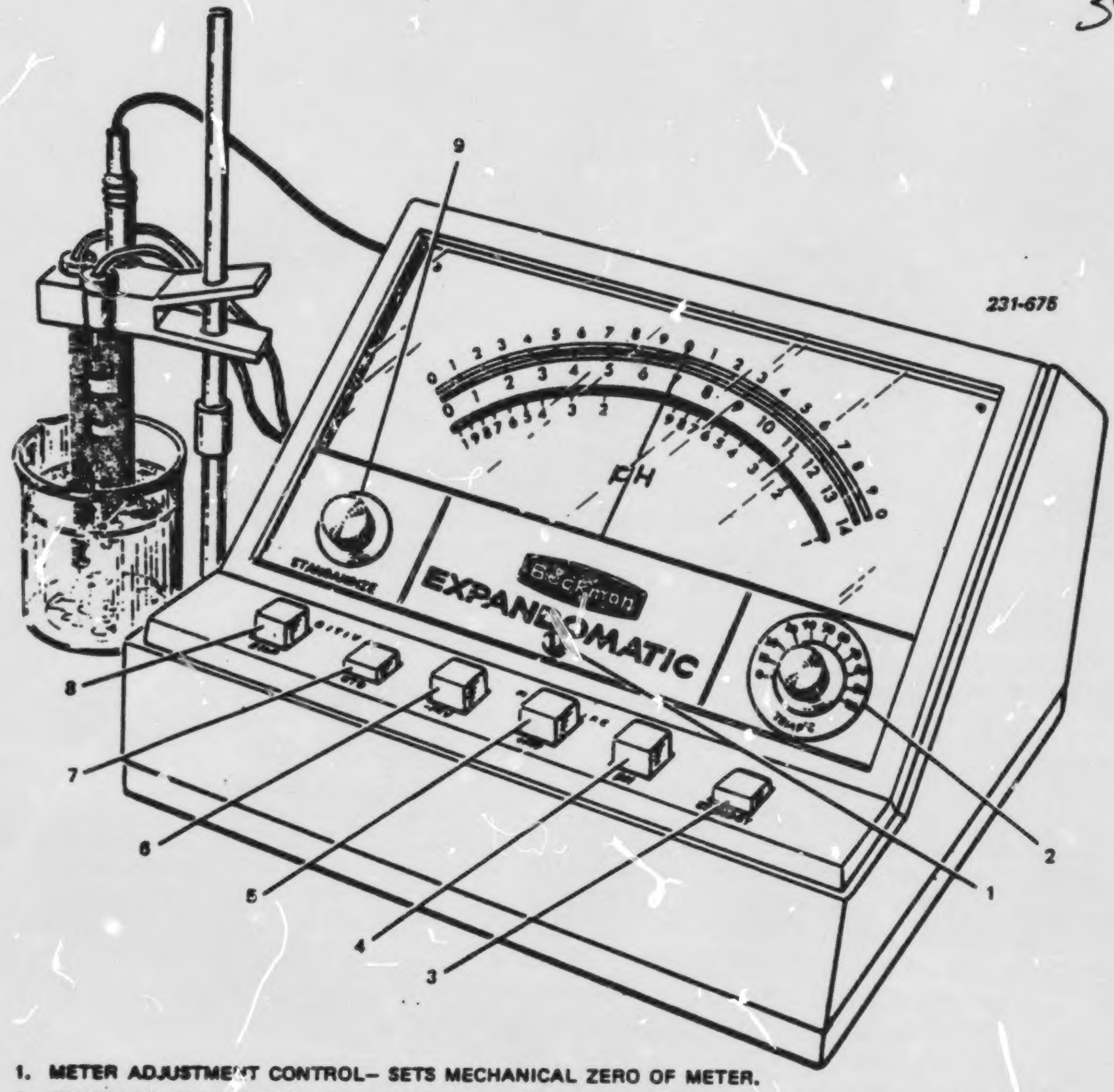
c. STANDBY PUSHBUTTON—Electrically disconnects glass electrode to prevent polarizing it and to prevent violent meter displacement when electrodes are removed from solution.

d. pH PUSHBUTTON—Switches in circuit for pH measurements.

e. +MV PUSHBUTTON—Selects circuit for millivolt measurements so that values on right-hand side of zero-millivolt point on scale are positive.

f. −MV PUSHBUTTON—Selects circuit for millivolt measurements so that values on right-hand side of zero-millivolt point on scale are negative.

g. STANDARD SCALE PUSHBUTTON—



1. METER ADJUSTMENT CONTROL– SETS MECHANICAL ZERO OF METER.
2. TEMPERATURE COMPENSATOR CONTROL– VARIES CIRCUIT GAIN TO FOLLOW CHANGE OF pH–MILLIVOLT SPAN WITH SAMPLE TEMPERATURE.
3. STANDBY PUSHBUTTON– ELECTRICALLY DISCONNECTS GLASS ELECTRODE TO PREVENT POLARIZING IT AND TO PREVENT VIOLENT METER DISPLACEMENT WHEN ELECTRODES ARE REMOVED FROM SOLUTION.
4. pH PUSHBUTTON– SWITCHES IN CIRCUIT FOR pH MEASUREMENTS.
5. +MV PUSHBUTTON– SELECTS CIRCUIT FOR MILLIVOLT MEASUREMENTS SO THAT VALUES ON RIGHT–HAND SIDE OF ZERO–MILLIVOLT POINT ON SCALE ARE POSITIVE.
6. –MV PUSHBUTTON– SELECTS CIRCUIT FOR MILLIVOLT MEASUREMENTS SO THAT VALUES ON RIGHT–HAND SIDE OF ZERO–MILLIVOLT POINT ON SCALE ARE NEGATIVE.
7. STANDARD SCALE PUSHBUTTON– SWITCHES IN CIRCUIT FOR SPAN COVERING 0 TO 14 pH AND 0 TO ± 1400 MV ON STANDARD SCALE.
8. EXPANDED SCALE PUSHBUTTON– INCREASE CIRCUIT SENSITIVITY SEVENFOLD OVER STANDARD SCALE TO PERMIT READINGS ON EXPANDED SCALE.
9. STANDARDIZE CONTROL– PROVIDES VARIABLE POTENTIAL OF UP TO 1300 MV TO STANDARDIZE ELECTRODE SYSTEM AND TO SET DESIRED ZERO POSITION FOR SCALE SHIFTING.

Figure 6-3. Expandomatic pH meter operating controls.

Switches in circuit for span covering 0 to 14 pH and 0 to ± 1400 mv on standard scale.

h. EXPANDED SCALE PUSHBUTTON—Increases circuit sensitivity sevenfold over standard scale to permit readings on expanded scales.

i. STANDARDIZE CONTROL—Provides variable potential of up to 1300 mv to standardize electrode system and to set desired zero position for scale shifting.

j. THERMOCOMPENSATOR SWITCH—Selects circuit for manual or automatic temperature compensation in pH measurements. (On back of instrument.)

2. Measurement of pH. A precise pH measurement of an unknown sample actually involves two measurements. The first measurement is of a buffer solution, the pH of which is known precisely at any given temperature, for the purpose of establishing a point of reference. The second measurement is of the sample, with the pH value given relative to the buffer. If the instrument is equipped with a thermocompensator (Thermocompensator Switch on Auto), references to setting of the Temperature Compensator Control may be disregarded in the following procedures.

3. Electrode Standardization. The following steps cover the standardization procedure:

a. Depress Standby Pushbutton.

b. Pour buffer solution into small beaker to depth of about one inch.

c. Uncover filling hole of reference electrode. Check the level of the electrolyte solution in electrode. For maximum stability the tip of the new glass electrode must be soaked for several hours before use.

d. Rinse electrode and laboratory thermometer tips in distilled water and, with laboratory tissue, blot off excess water.

e. Note temperature of buffer solution, set Temperature Compensator Control at that temperature, and turn Thermocompensator Switch to MANUAL.

f. Immerse tips of electrodes in buffer solution by positioning electrode clip on support rod.

g. Depress pH Pushbutton and Standard Pushbutton. Allow about one minute for reading to stabilize. If Thermocompensator is used, it may take up to five minutes to stabilize.

h. Adjust Standardize Control until meter reading corresponds with pH of buffer at temperature measured in step e. A temperature-correction table is on each Beckman Buffer Solution container. If instrument is being standardized with the expanded scale, designate three zero positions on scale as appropriate numbers that will include pH values of buffer and sample solutions, and set Range Indicator at 2-pH span included on expanded scale.

i. Depress Standby Pushbutton.

j. Remove electrodes from buffer solution, rinse their tips in distilled water and, with laboratory tissue, blot off excess water. Proceed with pH measurement as described in the following paragraphs.

4. pH Meaurements. Standardize instrument with proper buffer solution as described in previous paragraph.

a. Depress Standby Pushbutton.

b. Rinse thermometer and electrode tips in distilled water and, with laboratory tissue, blot off excess water.

c. Immerse tips of thermometer and electrodes in sample solution.

d. Set Temperature Compensator Control at temperature of sample solution.

e. Depress Standard Scale Pushbutton.

f. Depress pH Pushbutton.

g. Read pH value of sample on standard scale.

5. Expanded Scale pH Measurements. Standardize the instrument with proper buffer solution as described in previous paragraph.

a. Depress Standby Pushbutton.

b. Rinse thermometer and electrodes in distilled water and, with laboratory tissue, blot off excess water.

c. Immerse tips of thermometer and electrodes in sample solution.

d. Set Temperature Compensator Control at temperature of sample solution. If expanded scale is set to other than 6 to 8 pH range, sample-solution must be same as temperature of buffer used to standardize instrument.

e. Depress Expanded Scale Pushbutton.

f. Depress pH Pushbutton.

g. Read pH value of sample on expanded scale.

NOTE: WHEN TAKING A METER READING, ALWAYS OBSERVE THE NEEDLE SO THAT IT COVERS ITS OWN REFLECTION IN THE SCALE MIRROR; PARALLAX WILL CAUSE AN INACCURATE READING.

Factors that influence accurate readings. To insure top quality results when making pH meter readings, consider the following factors:

1. Electrodes are very fragile; never let the tips touch the bottom of the beaker.

2. Never remove electrodes from solution *if the READ or pH PUSHBUTTON is depressed.*

3. Keep electrodes clean—rinse them with de-ionized water, and blot excess water with chemically inert absorbent tissue before immersing them in the buffer or sample. Contaminated electrodes will cause drifting in the pH readings.

4. The filling hole on the reference electrode should always be covered when not in use.

5. Always check the level of the KCL in the reference electrode; if not full, bring it back up to the correct level.

6. Always leave the tips of the electrodes immersed in de-ionized water or a buffer of 7 when not in use.

7. Check the Buffer Temperature Table to insure the correct pH of the buffer solution.

8. Do not stir the buffer or test solution with electrodes in the beaker.

9. The pH of any given formula will vary somewhat from one contactor lot to another, and each laboratory will have to make a series of readings from each solution that is to be checked.

Exercise (660):

1. Complete statements on the operation of a pH meter.
   a. The purpose of the ______ electrode is to provide constant voltage.

   b. The reference electrode is filled with ______ .

   c. The ______ electrode measures the hydrogen concentration of the sample.

   d. ______ solutions are used to standardize a pH meter.

   e. A buffer of ______ is used to standardize the pH meter for checking a developer.

   f. A buffer of 4 is used to standardize the pH meter for checking an ______ solution.

   g. When cleaning an electrode, the meter should be in _________ .

   h. In determining pH, your first measurement is of the ______ solution.

   i. Electrodes should be cleaned with ______ water.

   j. When using the expandomatic, you can use the ______ scale to increase sensitivity sevenfold.

   k. Contaminated ______ will cause the pH reading to drift.

6-5. Specific Gravity

Specific gravity is the first test that you should perform on any freshly mixed solution of photographic chemistry. In this section we will explain how this most important test is performed.

661. Define specific gravity and explain principles and techniques used to determine specific gravity.

Specific Gravity Analysis. Specific gravity is defined as the ratio of the mass of a given volume of a substance to an equal volume of distilled water at the same temperature. As a formula, this would be:

$$\text{Specific gravity} = \frac{\text{mass of a known volume of a substance}}{\text{mass of equal volume of distilled water}}$$

The first check that should be made on all solutions is the specific gravity. It is a quick check to see if the mix is complete. Specific gravity is the ratio of the weight or mass of a given volume of a substance to an equal volume of distilled water at 60°F, which has an assigned specific gravity of 1. We know the specific gravity of each element and from this we can determine the specific gravity of any given ratio. The specific gravities for all of our processing solutions have been determined and will remain constant, provided the solution has been mixed in the proper proportions.

Specific gravity will, however, vary from one batch of solution to another because of various factors involved (quality of chemicals, inaccurate scales used in measuring chemicals, etc.). Because of this, upper and lower control limits must be set. If specific gravity of a solution does not fall within these control limits, further analysis can be made to determine the cause. If the specific gravity goes beyond the upper control limit, it might indicate that more than the formula amount of an ingredient has been used, a foreign ingredient has been used, or the solution has not been diluted properly. A specific gravity which is below the lower limit might indicate that an ingredient has been left out of the solution, or that too much water has been added.

The hydrometer is used for specific gravity checks. It must be cleaned before use, to give accurate readings. The hydrometer is calibrated to read 1.00 in pure, distilled water at 60°F. A temperature change will have a direct effect on the specific gravity reading. For every increase of 5°F, .001 must be added to the reading on the hydrometer. For a decrease of 5°F, .001 must be subtracted.

Since most photographic solutions contain several solids dissolved in the water, their density is not the same as the density of distilled water. The coefficient of expansion of any solution denser than water is greater than the coefficient of expansion of water. Therefore the photographic solution will expand more

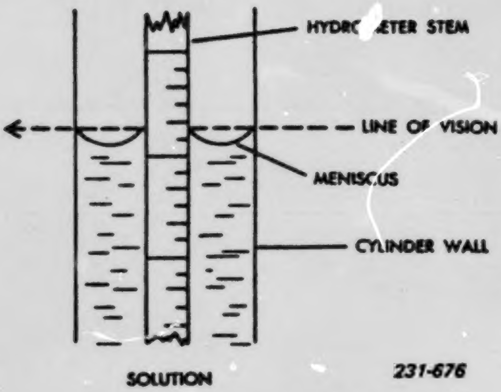


Figure 6-4. Section of hydrometer stem.

for each degree of temperature change. Laboratory research indicates that the temperature correction for most photographic solutions whose specific gravity falls between 1.100 and 1.200 is very close to 0.003 per 10°F temperature change.

Use of the Hydrometer. Using a hydrometer with a suitable range, insert it into the solution in the proper cylinder and record the reading from the scale on the stem of the hydrometer. The cylinder must be on a level support, and the reading taken from a point perpendicular to the side of the cylinder, at the top of meniscus. (See fig. 6-4.)

The following are sample specific gravity readings for solutions you are likely to use each day:

Solution	*Specific Gravity*
D-19	1.127
DK-50	1.034
D-76	1.089
D-72	1.105
Hypo	1.074

Exercises (661):

1. Define specific gravity.

2. Why is a specific gravity test performed on freshly mixed chemistry?

3. A specific gravity reading which is too high would indicate what problem(s)?

4. A hydrometer is calibrated to read what value?

5. What compensation do you have to make if a hydrometer reading of a developer is made in a solution having a temperature of 80°F?

6. At what point is a reading made on a hydrometer?

6-6. Solution Certification

Although there are several reasons for certifying photographic solutions, the principal one is to insure that they produce predictable and repeatable results. Depending upon the criticality of the mission, certification may be limited or extensive. For example, some noncritical operations may require no more than the statement of the chemmix technician that the solutions were properly prepared, whereas highly critical missions require complete chemical certification. It is up to the individual laboratory to decide which procedures are needed to meet mission requirements. The normal sequence is to take specific gravity, pH and sensitometric tests of the chemistry.

NOTE: Our discussion of solution certification is aimed at the developer solution. Specific gravity and pH tests, however, should be applied to all the solutions with the additional sensitometric test applied to the developer.

662. List and explain the purpose of each step that is performed in certifying a photographic solution.

Certifying Chemistry. Take a sample from the chemistry to be certified. The first test should be to measure the specific gravity. This determines whether the chemistry was properly mixed. If the specific gravity reading is high, it means that there is too little water and/or too much ingredients. If the reading is low, it means too much water or too few ingredients. If the chemistry is properly mixed, then you should take a pH reading. The pH reading indicates the proper strength of the solution. The strength of the solution determines its activity. Too much activity can lead to over-processing, and a too-weak solution leads to inadequate development. After these two tests have been performed, a sensitometric test is performed.

A sensitometric test involves processing a sensitometric strip through your chemistry and then reading the strip on a densitometer. The values from this strip are then read on a densitometer and plotted on graph paper so that they can be compared with established standards.

NOTE: Sensitometry will be better understood when we study the operation of a sensitometer and densitometer and the making of graphs. Right now, consider a sensitometer as a machine which gives a piece of film a known and repeatable exposure. The exposure is made through a graded step tablet (gray scale) that prints 21 steps of increasing density on the film. You use the same kind of film for the test as the film you use on your missions. The film is then processed according to directions.

Once the film has been exposed, processed, and finished, it is read on a densitometer. A densitometer is a machine that passes light through the film and then measures the change in light intensity caused by the different densities. These changes are visible on a meter. Each of the 21 steps is read and the values recorded. These values are then plotted on graph paper to form a characteristic curve. This curve then can be compared with a standard that has been established. By comparing these curves you can determine the performance of your developer.

Exercise (662):

1. List and briefly explain the purpose of each step that is performed in certifying a developer solution.

6-7. Sensitometers

The first requirement of a sensitometer is that it conforms to practice. It should produce exposures that are as nearly like camera exposures as we can make them, and that duplicate is, as nearly as possible, the color (spectral quality) of light used to make camera exposures. If we want to know how film responds to daylight, the light source in our sensitometer should closely approximate daylight. If we are concerned with the behavior of film under artificial light, we should use approximately the same quality of artificial light in our sensitometer.

Since a photographic exposure is the product of light intensity, the (I) and the (T) of light duration, the exposure steps produced by a sensitometer can be the result of varying either factor. If time is held constant while the intensity is varied, we have an intensity scale sensitometer; and if the intensity is held constant while the time is varied, we have a time-scale sensitometer. Sensitometers have been constructed using both principles; however, the intensity scale type is the standard today because time scale sensitometers can cause reciprocity problems with some types of films.

Another requirement is for an exposure modulator which gives you a graded series of accurately measured exposures needed to produce your sensitometric strip. An exposure modulator should meet the following requirements:

- It should operate over an exposure range that includes all of the exposures encountered in practice.
- Should be accurate and consistent.
- Should have no significant effect on the color quality of the light.

663. Complete statements on the nomenclature, operation, and application of sensitometers.

Intensity-Scale Sensitometers. When film is exposed in a camera, a frame stops momentarily behind the lens and the shutter opens for a predetermined period and then closes. The frame has received an exposure, but in reality, it has received as many exposures as there are different tones in the scene. Each object that reflects a different amount of light produces its own exposure and its own corresponding density. Thus, camera exposures are, in fact, intensity modulated. Since we require that sensitometer exposures conform to practice, it stands to reason that the exposure it produces should be intensity modulated.

The most commonly used intensity-scale modulator is simply an accurately made step-wedge. To provide a scale of equal percentage exposures, it is only necessary that the wedge have equal density differences between adjacent steps. This is true because density is the logarithmic function of the transmission for any step.

Mark VI Sensitometer. The Mark VI sensitometer is an example of an intensity scale sensitometer (see fig. 6-5). It employs an electronic flash tube as its light source, and its exposure times vary according to the circuit selected. The instrument operates on 115-volt 60-cycle current.

The electronic flash tube emits light that is a close approximation of daylight, and it can be used without color compensation (i.e. filters) except where a test requres the color temperature of tungsten light. Three circuits permit exposure times of 10^{-2} (1/100), 10^{-3} (1/1000), and 10^{-4} (1/10,000) of a second, and the intensity of the tube varies with the exposure time selected. The 1/100-second exposure is approximately 1000 meter candle seconds, the 1/1000-second setting produces approximately 5000 meter candle seconds, and the 1/10,000-second setting gives an exposure of 130-meter-candle seconds.

To operate the instrument, follow these steps.

a. Plug the power cord into an outlet. Be sure to ground the plug to prevent a shock hazard.

b. Switch the power on.

c. Press the exposure circuit selector for desired flash duration.

d. Add filters or light attenuators if necessary. The variable area filters (attenuators) having 3 or 19 lines are inserted between the flash-tube shield and the gray-scale box. They allow the user to balance the light output of the three separate circuits within ± 10 percent. The 3-line filter and the 19-line filter, which can be considered equivalent to Neutral Density 1.70 and 1.0 respectively, are used to normalize the light output of the 10^{-3} and 10^{-2} circuits to that of the

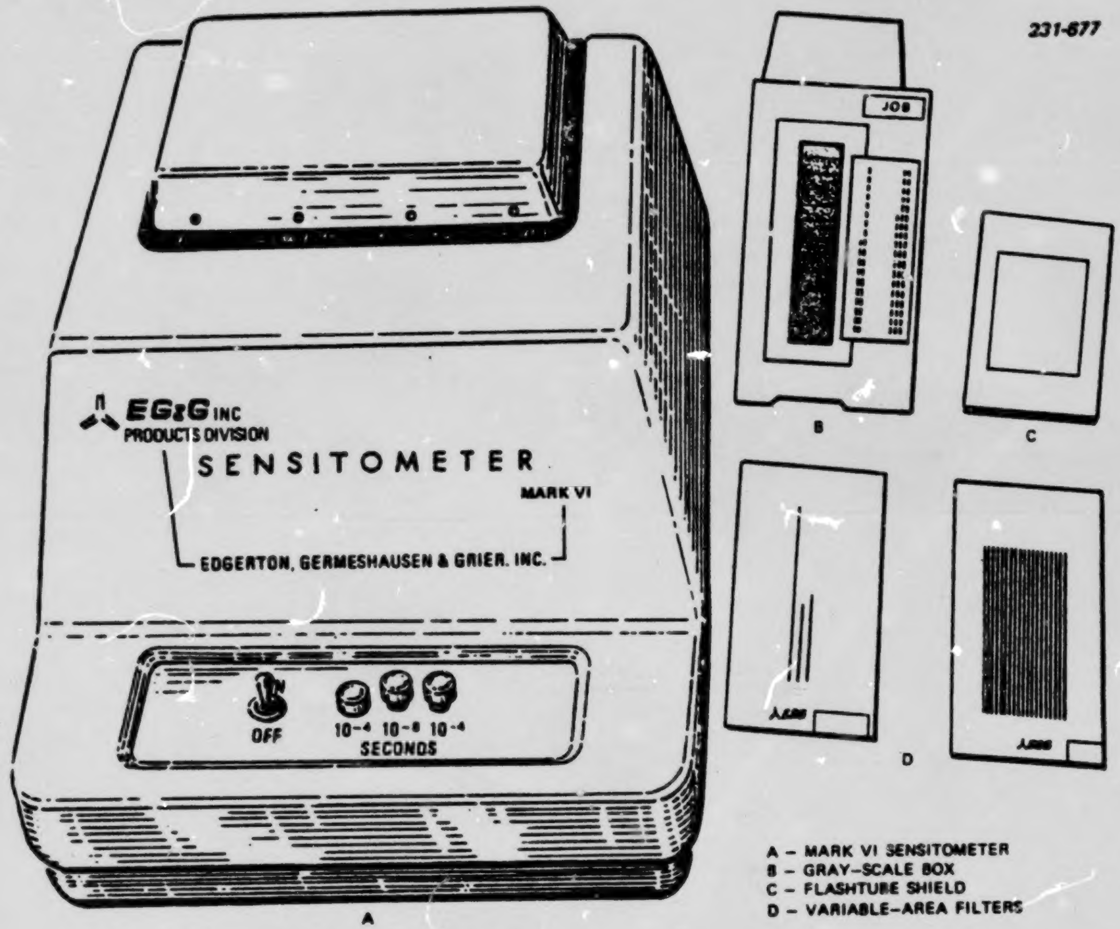


Figure 6-5. Complete Mark VI system.

10^{-4} circuit. Normalization of the light output of the three circuits can be useful in studying film characteristics. In addition to the area filters, neutral density filters can be added, as follows, with films having a variety of speeds.

ASA NUMBER	*Neutral Density Filter*
10	1.0
32	1.5
100	2.0
320	2.5
1000	3.0
3200	3.5

e. Turn the room lights off.

f. Place the film to be exposed over the step tablet, emulsion down.

g. Slide the film into the proper groove.

h. Hold the film in place at one end and lower the sponge rubber platen onto the film.

i. Flip the top down, activating the microswitch. A small amount of light may be visible at the edges of the platen, but this will not damage the film. If there is a large light leak, check the setting of the microswitch. If the microswitch is set too low, the tube will fire before the platen covers the film.

j. Process the film as usual.

NOTE: Each step of the testing process must be done with care to insure the necessary repeatability that data collecting requires.

Many labs now used pre-exposed strips that are produced by Kodak. The strips are kept refrigerated until needed and then pulled out for running a test. This eliminates the requirement for a sensitometer in many instances.

Exercise (663):

1. Complete statements on the use of a sensitometer.
   a. An __________ scale sensitometer closely duplicates a camera exposure.

b. A Mark VI sensitometer has an ______ ______ light source.

c. An exposure on a sensitometer is measured in ______ ______ ______.

d. ______ are used to balance the light output of the three separate circuits on the Mark VI.

e. It is important that each step of sensitometry be done with care to insure __________.

6-8. Densitometers

Your exposed sensitometric strip has been processed and this brings us to the next part of the sensitometric control—the measurement of the densities produced on your test material. This is the extent of densitometry—it is the gathering of

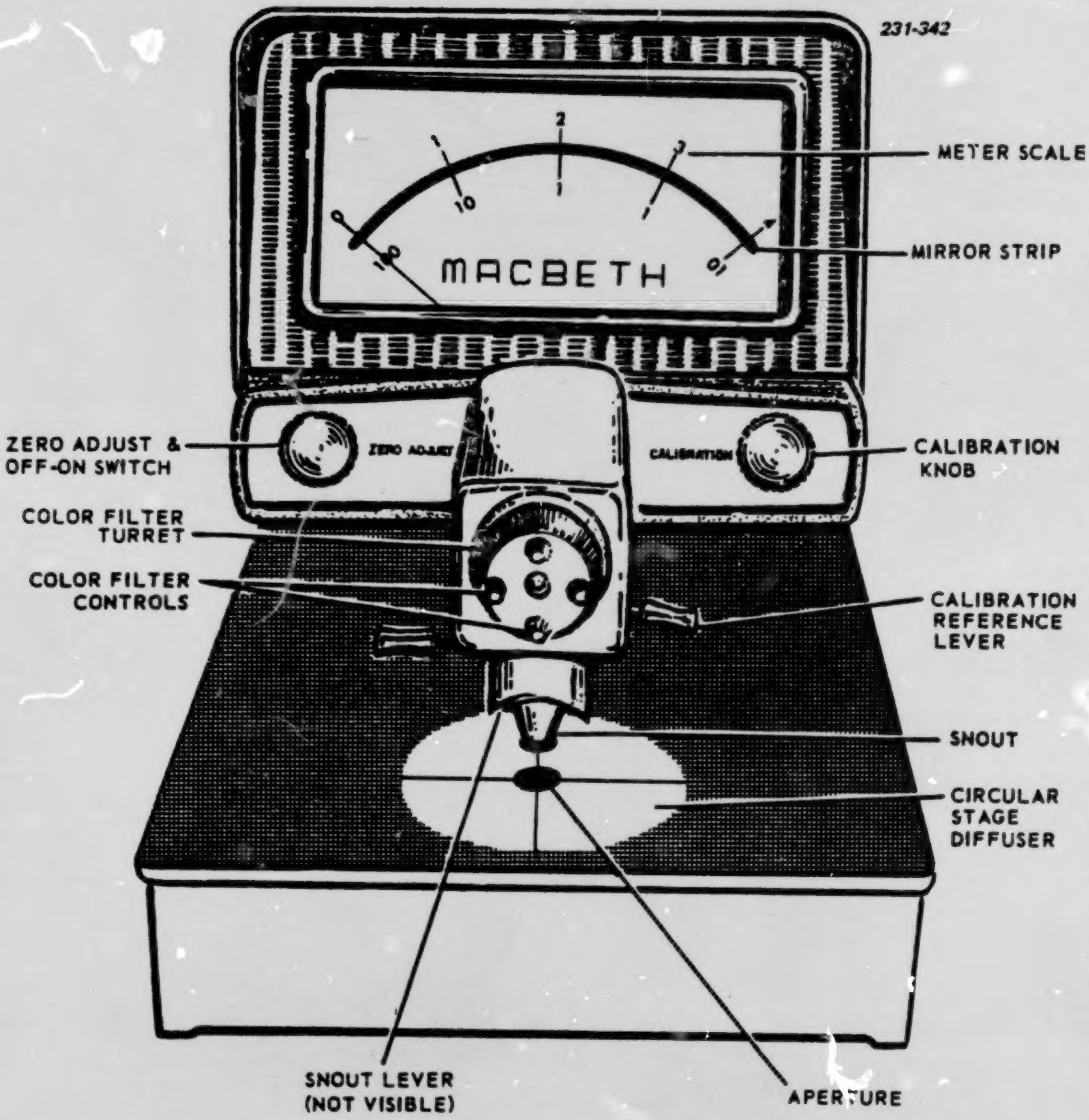


Figure 6-6. MacBeth quantalog densitometer.

information needed to determine the photographic characteristics of light sensitive material (the aim of sensitometry). Densitomery involves the use of densitometers for obtaining data about the material being tested. A densitometer is an instrument for measuring and reading directly, in terms of density, the light stopping ability of films or prints. The most common type of densitometer is the photoelectric type.

664. Complete statements on the nomenclature and operation of densitometers.

Photoelectric Densitometers. Photoelectric densitometers employ a photoelectric cell or similar detector to determine the intensity of light. The most widely used photoelectric densitometers are the direct reading type. To use these densitometers, place the material to be measured in the light beam between the source and the photocell and read the density value directly from a meter. Since the measurements are not dependent upon visual impressions, this type of densitometer is much easier to use than the older visual comparison densitometer. It is, however, very important to keep photoelectric densitometers properly calibrated and to maintain a constant light source through voltage stabilization.

TD-102 Densitometer. The MacBeth Quantalog Densitometer, TD-102, shown in figure 6-6, is typical of the kind of instrument that is generally used. The instrument contains a power transformer which provides either 115- or 230-volt operation at frequencies of 50 and 60 cycles per second. Your instrument is usually wired for 115-volt, 60-cycle operation, and this information should be shown on the data tag attached to the back of the instrument. If it is necessary to change voltage, send the instrument to your maintenance section.

The total power consumption of the TD-102 is approximately 60 watts. This includes the power needed to operate the electronic circuits, the light source for the optical system, and the antifatigue lamp. The electronic power supply is self-regulated and is not affected by normal variations in line voltage. However, the light source for the optical system is affected by line voltage fluctuations, and a voltage regulator must be used in conjunction with the instrument. You can readily see that if the light passing through a sample fluctuates, the density reading also fluctuates. A simple 60-volt ampere regulator is adequate.

You may use the TD-102 under any normal lighting conditions, since ambient light does not affect its optical system. However, since the dial is not illuminated, you must provide a light for it if you plan to use the instrument in a darkroom.

Optically the TD-102 meets ANSI standards for measuring diffuse transmission density. The instrument is equipped with a turret containing four filter positions. The filters installed in the turret are the red, Wratten No. 92; the green, Wratten No. 93; the blue, Wratten No. 94; and a No. 106 for visual operation. For color densitometry you use the three colored filters; for black-and-white densitometry you place the turret in the visual position.

The meter scale on the TD-102 is linear from 0 to 4.0 density units. The scale is divided into 200 equal graduations of 0.02 density units each. You can make density readings that are precise within a tolerance of ± 0.02 density units. By reading between graduations, you can make readings of ± 0.01 density units.

The circular stage diffuser is $3\frac{3}{4}$ inches in diameter, with a circular aperture of 2 mm (0.079 inches) in diameter at its center. The diffuser has a brightness of approximately 100 foot-lamberts.

Densitometer Operation. Except for minor differences, all densitometers are used in the same way. Therefore, to learn how to operate a densitometer, let us take the TD-102 as being typical. When we talk about zeroing and adjusting this instrument, we shall include the color filters, even though our immediate concern is with black-and-white operation.

Refer to figure 6-6 and you will see that all controls are on the front of the instrument. Locate each control in the illustration as you go through the following operations. To zero-adjust the TD-102:

(1) Rotate the zero-adjust switch to turn the power on, once the instrument has been plugged into a suitable power line whose voltage is stabilized with a voltage regulator.

(2) After a 30-minute warmup, with no sample in place and the filter selector control rotated to the visual filter position (the gold filter trim control in the bottom position), depress the snout lever. Turn the zero-adjust switch further clockwise until the needle is properly zeroed.

NOTE: When making any reading, remember to use the built-in mirror to prevent parallax errors.

(3) Step 2 is then repeated with the red, green, and blue trim controls in the bottom position. This zeroing is necessary only for color work.

To calibrate the TD-102 after zeroing:

(1) Place the internal calibration reference in the measuring beam by moving the calibration reference control backward (toward the machine) until you feel it "click in."

(2) Depress the snout lever.

(3) Adjust the calibration control until the meter reads the density indicated on the tag adjacent to this control.

(4) Remove the internal calibration reference from the measuring beam by moving the calibration reference control forward until you feel it "click out." (The calibration reference control must be "out" when making a reading.)

(5) Recheck your zero and calibration settings. The machine should "hold" both proper zero and calibration at the same time.

STEP NO.	DENSITIES			$\bar{D}$
1	0.10	0.11	0.09	0.10
2	0.14	0.13	0.13	0.13
3	0.16	0.14	0.15	0.15
4	0.22	0.18	0.20	0.20
5	0.28	0.27	0.26	0.27
6	0.39	0.35	0.37	0.37
7	0.51	0.52	0.48	0.50
8	0.66	0.64	0.65	0.65
9	0.78	0.80	0.82	0.80
10	0.94	0.96	0.95	0.95
11	1.08	1.10	1.12	1.10
12	1.23	1.27	1.25	1.25
13	1.38	1.40	1.42	1.40
14	1.53	1.55	1.57	1.55
15	1.69	1.71	1.70	1.70
16	1.80	1.84	1.81	1.82
17	1.90	1.94	1.92	1.92
18	1.99	2.01	2.00	2.00
19	2.04	2.08	2.06	2.06
20	2.14	2.10	2.11	2.12
21	2.13	2.17	2.15	2.15

Figure 6-7. Charts for recording sensitometric strip densities.

NOTE: Fine needle adjustments can be made by rotating the filter trim control knob that is being used.

Once you have determined that your densitometer is in calibration and is operating correctly, you are ready to make density readings of your sensitometric strips. It is most convenient to work with another technician when making density readings. One person should operate the densitometer, calling out the density values as they appear on the meter dial, while another person lists the values on a specially prepared form, such as is shown in figure 6-7. Notice that there are three columns in which to record densities. The reason is this: Since operator errors, as well as systematic errors (those inherent in, or produced by, the system) are likely to occur, you can get a more realistic evaluation of density by taking three replicate readings and averaging them. The chart shown in figure 6-7 provides a column headed $\bar{D}$ for the average densities. Notice we said replicate, not duplicate, readings. These are made by reading the entire strip, recording the individual step densities in the first column; reading and recording the entire strip a second time for the second column; and doing the same thing for the third column. You should not try to read the same spot on each step, nor should you try to hit the same spot for each replication. Because there may be flaws in emulsions or in development, an unrealistic density may occur in a particular spot; if your densitometer read this spot three times in succession, you would get an erroneous value for the step. Make your readings as random as possible. Do not try to hit the same spot each time. Just read and record each strip three times and then average the values for each step.

Exercise (664):

1. Complete statements on the nomenclature and operation of the TD-102 densitometer.
   a. _____ densitometers are easier on the eyes than the _____ _____ type.
   b. The TD-102 densitometers have _____ filter positions.
   c. The _____ filter is in the bottom position when zeroing the TD-102.
   d. For color work, you must zero with the _____, _____, and ________ .
   e. After zeroing, a densitometer is then checked for ________ .
   f. When reading a control strip, you should make ________ readings.

6-9. Replenishment Procedures

The need for replenishment arises from many different factors. Of importance are the following:

- As photographic solutions are used, chemical components are used up.
- As chemical components are used up, byproducts are formed in the processing solution.
- The combined action of losing chemicals and gaining byproducts ultimately makes the processing solution ineffective.
- It is not always feasible to shut down processing machines so that the chemical solutions can be changed whenever they begin to deteriorate or whenever they begin to approach exhaustion.

As we have previously discussed, the best way to check your solutions is through performing pH, specific gravity, and sensitometric tests. This testing will indicate the need for replenishment.

In this section we are going to discuss logarithms which are the mathematics used in sensitometry—the drawing of characteristic curves which give you visible proof of your developer's performance. Finally, we will discuss the steps in replenishing developers, stop baths, and fixing baths.

665. Give the definition and some characteristics of logarithms, and solve log problems.

Logarithms. A logarithm is a number used to represent another number. Logarithms were originated as a means of simplifying the handling of numbers containing a large number of digits or decimal places. They are commonly used in scientific research to reduce complicated multiplication and division problems to simple addition and subtraction.

We can best define a logarithmic series of numbers by first considering an arithmetic series of numbers. The following are arithmetic series of numbers:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9 . . . . .
0, 2, 4, 6, 8, 10, 12, 14, 16 . . . . .
5, 10, 15, 20, 25, 30, 35, 40 . . . . .

In the first series of numbers we are only adding 1 to the previous number to get the next. In the second series of numbers we are simply adding 2 each time to the previous number to get the next. In the third set we are simply adding 5 to the previous number to get the next number.

Suppose we wanted to evaluate the response of a photographic material to different amounts of exposure. We would expose the material with a series of exposure increments. We might use a series of exposures increasing the increments of 5, 10, 15, 20, and so on. Notice that there is not a uniform increase in exposure from one increment to the next. The exposure from 5 to 10 represents a 100-percent increase, whereas the exposure from 10 to 15 is only a 50-percent increase. The increase of exposure from 15 to 20 is only a 25-percent increase. Thus, as the exposure gets greater, the percent of increase becomes smaller.

To effectively analyze a photographic material, we must give it exposure increases at regular intervals. For example, if we start with 5 and multiply each exposure to our material by a factor of 2, we would produce a series of equal exposure increases. Our steps would progress 5, 10, 20, 40, etc. This is an example of geometric progression. This is a series of logarithmic numbers. The following are examples of logarithmic series of numbers.

1, 2, 4, 8, 16, 32, 64, ...
5, 10, 20, 40, 80, ...

A logarithmic series of numbers is the result of multiplying or dividing the previous number by a certain number to get the next number. Notice in the previous group of numbers we multiplied each number by the factor of 2 to get the next one. The following is another group of logarithmic series of numbers.

1 10 100 1,000 10,000 100,000 1,000,000

In the last series, we multiplied the previous number by 10 each time to get the next number, as shown here:

1
10 (10x1)
100 (10x10)
1,000 (10x10x10)
10,000 (10x10x10x10)
100,000 (10x10x10x10x10)
1,000,000 (10x10x10x10x10x10)

The above series of numbers can also be expressed in the following way:

$10^0 = 1$
$10^1 = 10$
$10^2 = 100$
$10^3 = 1{,}000$
$10^4 = 10{,}000$
$10^5 = 100{,}000$
$10^6 = 1{,}000{,}000$

In this last series of numbers, we use the number above and to the right of the tens to indicate how many tens we must multiply together, by ten, to get the equivalent numbers. These numbers are called exponents or powers. An example $10^3 = 1{,}000$ (10x10x10 = 1,000). In this case, 3 is the exponent and tells us how many tens to multiply together.

Logarithms are actually the exponent by which we can raise some convenient base number (in this case 10) in order to describe some other number. For instance:

$$10^4 = 10{,}000$$

Logarithms to the base 10 are called common logarithms. Another way to express $10^4 = 10{,}000$ (ten raised to the fourth power equals ten thousand) would be: $\text{Log}_{10}\ 10{,}000 = 4$ (the logarithm to the base 10 of 10,000 equals 4). It is common practice to omit writing the base if the base is 10, but to write it in for logarithms using bases other than 10. Now we simply say the Log of 10,000 = 4. (The number to take the place of 10,000 is 4). To understand this more, let us look at the powers of ten, their values, and their logarithmic form. (See fig. 6-8)

The logarithm number is made up of a whole number or a whole number and a decimal fraction. The numbers listed under logarithmic forms in figure 6-8 are logarithm numbers. The number to the left of the decimal is called the characteristic. The characteristic can be a positive or a negative number. A positive characteristic indicates the original number was a whole number or a mixed number. If the original number is a decimal, the characteristic is negative and is distinguished from the positive characteristic by a bar above the number. ($\overline{1}$, $\overline{2}$, $\overline{3}$, etc.)

Powers of 10	Common Number	Logarithmic Forms
10^6	1,000,000	6.0000
10^5	100,000	5.0000
10^4	10,000	4.0000
10^3	1,000	3.0000
10^2	100	2.0000
10^1	10	1.0000
10^0	1	0.0000
10^{-1}	.1	$\bar{1}.0000$
10^{-2}	.01	$\bar{2}.0000$
10^{-3}	.001	$\bar{3}.0000$
10^{-4}	.0001	$\bar{4}.0000$
10^{-5}	.00001	$\bar{5}.0000$
10^{-6}	.000001	$\bar{6}.0000$

Figure 6-8. Powers, Values and Logarithms

Figure 6-8. Common logarithms (base 10).

EXAMPLE: Log 100 =2,0000 (We can omit the decimal and the four zeros and use only the characteristic 2)

Log 0.001 = $\bar{3}.0000$ (Omit the decimal and the zeros and use only the characteristic $\bar{3}$)

We have expressed 13 numbers in figure 6-8, ranging from 1,000,000 to 0.000001 by their logarithms. What about all the numbers in between these that can't be expressed with a whole number exponent of 10? The number 25 falls between 10 and 100, which have characteristics of 1 and 2. Therefore the characteristic for the logarithm of 25 must be 1 plus some decimal fraction. This decimal fraction part of the logarithm is called the mantissa. The mantissa is always positive and is obtained from an appropriate table of logarithms.

To find the logarithm of a number you first determine the characteristic. This number may be determined by inspection. Only the mantissa is listed in the logarithm table. Let us set about the task of determining the logarithm of a number by first finding the characteristic.

The characteristic is the number to the left of the decimal point. When the given number is 1 or larger the characteristic is positive. When the given number is less than 1 the characteristic is negative and is so indicated by placing a bar above the characteristic.

At this point, for purposes of simplification, we will introduce a system that greatly reduces the difficulty usually encountered in determination of the characteristic. We call this the "CARET SYSTEM."

To determine the characteristic of a number, place a caret (‸) to the right of the first significant number. A significant number is any number other than zero. Now, count the number of digits between the caret and the decimal point. The number of digits will be the characteristic. If the decimal point is to the right of the caret, the characteristic will be positive. If the decimal is to the left of the caret, the characteristic will be negative.

EXAMPLE:

GIVEN NUMBER		*CHARACTERISTIC*
3‸72.	=	2.
3‸.72	=	0.
.007‸3	=	$\bar{3}.$
.3‸2	=	$\bar{1}.$

We use the simplified method mentioned above because some have difficulty committing to memory the rules that apply to characteristic determination. However, we recommend that you learn these rules to further your understanding of logarithms.

The following rules are used in determining the characteristic for a given number.

Rule 1. THE CHARACTERISTIC OF ANY WHOLE OR MIXED NUMBER IS *ONE LESS* THAN THE NUMBER OF FIGURES TO THE LEFT OF THE DECIMAL POINT.

Rule 2. THE CHARACTERISTIC OF A DECIMAL FRACTION IS EQUAL TO THE NUMBER OF PLACES TO THE RIGHT OF THE DECIMAL, *TO AND INCLUDING* THE FIRST SIGNIFICANT FIGURE.

A significant figure is any digit other than zero. Remember that the characteristic for a decimal figure is negative and a bar must be placed above the characteristic to indicate this.

EXAMPLE:

GIVEN NUMBER		*CHARACTERISTIC*
25,000.00	=	4
2,500.00	=	3

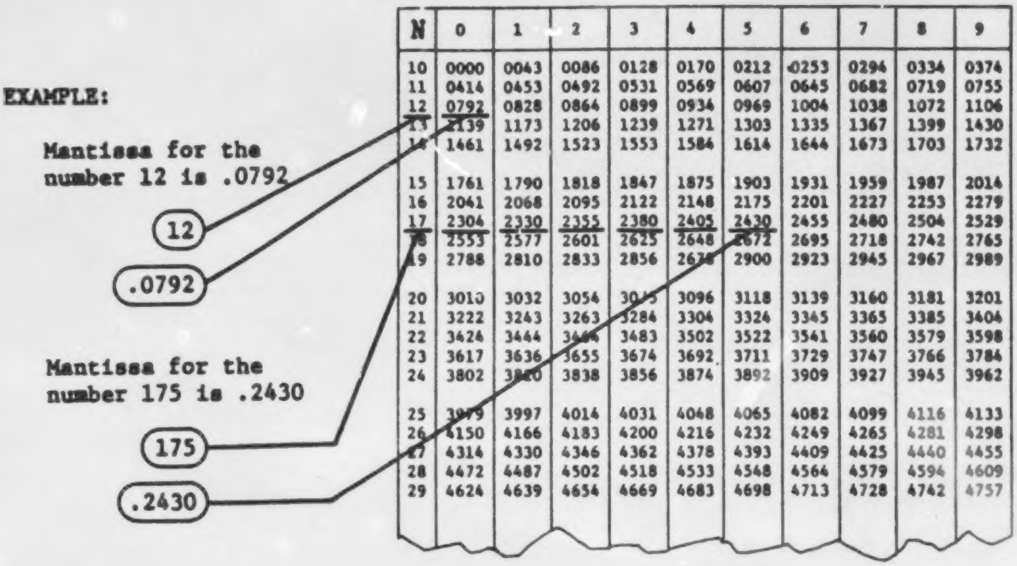
EXAMPLE:	*GIVEN NUMBER*	*CHARACTERISTIC*
(Rule 1)	250.00 =	2
	25.00 =	1
	2.50 =	0
EXAMPLE:	*GIVEN NUMBER*	*CHARACTERISTIC*
	0.00002 =	$\bar{5}$
	0.00023 =	$\bar{4}$
(Rule 2)	0.00236 =	$\bar{3}$
	0.02360 =	$\bar{2}$
	0.23600 =	$\bar{1}$

After you have applied the rules listed above and have determined the characteristic, there is still one more step to accomplish. As we have said before, a logarithm has two parts. You have found the characteristic, now you must find the mantissa.

To locate the proper mantissa, you must use a log table. The log table that has been provided in table 6-2 will enable you to find the mantissa for any 3-digit figure. If your given number contains more than 3 digits, you must either procure a table computed for these numbers or use a mathematical process called interpolation to determine the appropriate mantissa. Logarithm tables have been computed with mantissas having 14 digits or more. The greater the number of digits, the greater the accuracy of the table.

However, for our purposes, the 4-place table will provide sufficient accuracy. In the event you are called upon to determine the mantissa for a number having more than three figures, simply round off the number to 3 places and then determine the proper mantissa.

Look at your log table. You will see 11 columns of figures headed by the letter "N" and digits from 0 to 9. To determine the mantissa for any number having 3 significant figures, locate the number in the "N" column and then proceed across the chart horizontally until we reach the column headed by the third digit of the number. At this point on the chart, we will locate the mantissa.


EXAMPLE:
Mantissa for the number 12 is .0792
12
.0792
Mantissa for the number 175 is .2430
175
.2430

N	0	1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765
19	2788	2810	2833	2856	[illegible]	2900	2923	2945	2967	2989
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4455
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757

Numbers having identical significant figures but differing in the position of the decimal point will have the same mantissa. However, the characteristic will differ to indicate the difference in arithmetical value.

EXAMPLE: (Log .2 = $\bar{1}$.3010) (Log 2 = 0.3010) (Log 20 = 1.3010)

Anti-Logs. Now that you have learned the procedures for finding the logarithm of a number, let's tackle the problem from a different angle. Suppose that you were given the logarithm and told to find the number that it represents. How would you go about accomplishing this task?

Actually, the process is quite simple. Basically, the operation is the reverse of finding the logarithm. When we perform this operation, we are finding the anti-logarithm. The anti-log is the number that the logarithm represents.

Let us say, for purposes of illustration, that we want to find the anti-log of the logarithm 3.6990. First we go to the log table and scan the mantissas until we locate .6990. The numbers are arranged in an arithmetic progression that aids in locating the desired mantissa. This mantissa is located adjacent to the number 50, in the "N" column. Since all numbers with identical figures have the same mantissa, .6990 could represent the number 5, 50, or 500, etc. However, determining the specific value of the anti-log will present no problem if you use the following procedure.

Again, using the "CARET SYSTEM," take the

TABLE 6-2
LOG TABLE (COMMON LOGARITHMS)

COMMON LOGARITHMS.

N	0	1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4455
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172
33	5185	5198	5211	5224	5237	5250	5263	6276	5289	5302
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425
44	6435	6444	6454	6464	6474	6484	6494	6503	6513	6522
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987
63	7993	8000	8007	8014	9021	8028	8035	8041	8048	8055
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8180
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445
70	8451	8457	8563	8470	8476	8482	8488	8494	8500	8506
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9480
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680
93	9685	9689	9694	9699	9703	9708	9713	9717	9277	9727
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996

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number you found (50) and place a caret (‸) to the right of the first significant number. Now, place the decimal point to the right or left the number of spaces equal to the value of the characteristic. Place the decimal point to the right if the characteristic is positive and left if the characteristic is negative. Sometimes it is necessary to add zeros to determine the value of the characteristic. For simplicity, we can say that the characteristic indicates how many digits there will be between the first significant number and the decimal point. Please note the following examples:

EXAMPLE: *Determine the Anti-log of 3.6990*

LOG	ANTI-LOG
3.6990	5‸000.
$\bar{3}.6990$	.005‸
5.6990	5‸00000.

The following rules are used when you are finding anti-logs.

Rule 1. IF THE CHARACTERISTIC IS POSITIVE, THE NUMBER OF FIGURES TO THE LEFT OF THE DECIMAL POINT WILL BE *ONE MORE* THAN THE CHARACTERISTIC.

Rule 2. IF THE CHARACTERISTIC IS NEGATIVE, THE NUMBER OF PLACES TO THE RIGHT OF THE DECIMAL, *TO AND INCLUDING* THE FIRST SIGNIFICANT FIGURE WILL BE EQUAL TO THE CHARACTERISTIC.

EXAMPLE: *Logarithm* = *Anti-Logarithm*

4.3010 = 20,000

(Characteristic of 4 equals 5 decimal places in anti-log)

(Rule 1) 2.6990 = 500

(Characteristic of 2 equals 3 decimal places in anti-log)

(Rule 2) $\bar{4}.3010$ = .0002

Logarithm		*Anti-Logarithm*
(Characteristic of Bar 4 indicates the first significant figure will be in the fourth place from the decimal)		
$\bar{2}.6990$	=	.05
(Characteristic of Bar 2 indicates the first significant figure will be in the second place from the decimal)		

NOTE: To stress again, the reason you need to study logarithms is that the values given on pH meters and densitometers are given in terms of logs. Logs provide a convenient method by which large numerical values can be reduced to simplified form for easy use.

Exercises (665):

1. What is a logarithm?

2. How many parts are there to a logarithm?

3. Which part of a logarithm is always positive?

4. What base is used in the "COMMON SYSTEM" of logarithms?

5. How is a negative characteristic indicated?

6. How do you determine the characteristic for a logarithm?

7. Find the characteristics for the following numbers:

   a. 555.

   b. 2.46.

   c. 0.000443.

   d. 0.109.

   e. 44.5.

8. Find the mantissa for the following numbers:

   a. 3.

   b. 55.

   c. 0.0006.

   d. 0.07.

   e. 444,000.

9. Find the logarithms for the following numbers:

   a. 0.01.

   b. 19.5.

   c. 662,000.

   d. 0.000005.

   e. 8.0.

TABLE 6-3
RELATIONSHIP BETWEEN EXPOSURE, DENSITY, AND OPACITY

Step	*E (MCS)**	*Log E*	*Density (Log O)*	*Opacity*
1	0.001	$\bar{3}.0$	0.11	1.29
2	0.010	$\bar{2}.0$	0.20	1.58
3	0.10	$\bar{1}.0$	0.42	2.63
4	1.00	0.0	0.85	7.08
5	10.00	1.0	1.35	22.40
6	100.00	2.0	1.85	70.80
7	1000.00	3.0	2.23	170.00

*MCS is meter-candle seconds.

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10. Find the anti-log for the following logarithms:

a. 2.1847.

b. $\bar{3}$.0294.

c. 1.8825.

d. $\bar{1}$.7419.

e. 0.9004.

666. Explain the nomenclature and state the principles associated with the construction of characteristic curves.

Characteristic Curves. Up to this point you have learned how to expose and process sensitometric strips. Then you learned to read the results on a densitometer. Now you must be able to put these density readings to some use.

In order to analyze and understand the results of a sensitometric test, you must plot the density of each step in a test strip in relation to the exposure that was required to produce the density. A characteristic curve is drawn on a graph by plotting the densities (D) of the exposed and processed strip against the logarithms of their corresponding exposures (log E). This principle was originated by Messrs. Hurter and Driffeld a number of years ago, and the result is often called and H and D curve in their honor. It is also referred to as a D log E curve or a sensitometric curve.

Plotting characteristic curves. If the values of density (logarithm of opacity), as measured from a sensitometric test strip, are placed in a column opposite the logarithm of the exposures which produced them, the column will represent the relationship between exposures, densities, and opacities for that particular emulsion and a given processing condition. A typical example of these relationships is shown in table 6-3.

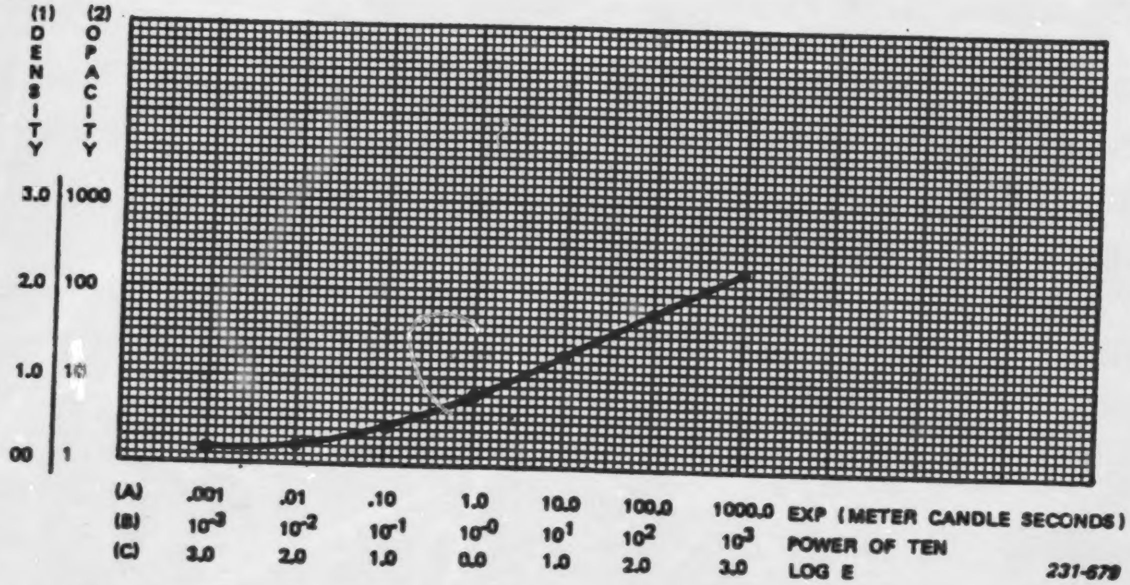

Figure 6-9. Characteristic curve.

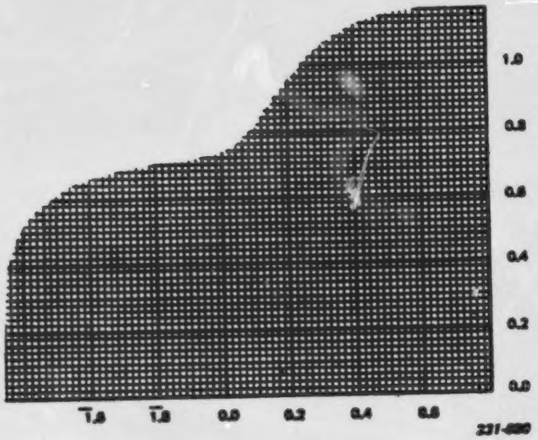

Figure 6-10. Making the horizontal and vertical axis.

Since the relationship between exposure and density is difficult to visualize from a table of this sort, it is much better to use a graphic representation, as shown in figure 6-9. In this graph (table 6-3 and fig. 6-9) the density (log 0) is plotted against the logarithm of the exposure (log E). Note that the exposures and densities are plotted in geometric progression so that mathematical values of equal progression, adaptable to standard graphing procedures, are obtained.

Determining log E for intensity-scale sensitometers. In an intensity-scale sensitometer the time of exposure is a constant. The illumination affecting the material being tested is varied by exposing through a step wedge. The density of each step of the step wedge reduces the exposure proportionately. So, in order to obtain the log E for each step, the density of that step is substracted from the log of the exposure (log E) at the exposure plane. *Example:*

Illumination at exposure plane = 105 MC (meter-candles)
Log illumination at exposure plane = 0.02
Time 4 sec
Log time 0.60
Log I = 0.02
Log T = +0.60
Log E (at exposure plane) = 0.62
Density of step 1 = 0.04
Log E of step 1 = 0.58

Intensity-scale sensitometers are provided with step wedges which are calibrated by the manufacturer. The manfacturer's values may be used, or the step density values may be determined with a densitometer.

Preparing the graph. For plotting a characteristic curve, it is convenient to use a graph sheet ruled 20 units to the inch (20 x 20 per inch) or 10 units to the half inch (10 x 10 per half inch). The base line should be marked off in even increments of 0.20 log E units to the half inch. It is necessary to provide enough spaces to accommodate the range of log Es for the 21 steps used to produce the strip being plotted. (Placing the 0.0 point on a line 2 inches from the right edge usually provides sufficient space.) Considering the base line as zero, mark off the vertical axis in increments of 0.20 density units per half inch, as shown in figure 6-10.

The log Es of the 21 steps are then plotted along the horizontal axis, as plotted in figures 6-11 and 6-12, and the corresponding densities of the test are plotted in their proper position above them, as plotted in figure 6-12.

Plotting density against density. Table 6-4 and figure 6-12 show how a test strip printed through a standard Eastman Sensitometric Step Tablet No. 2 could be read and plotted. This tablet consists of 21 steps, ranging in density from approximately 0.05 to 3.05. The density difference between each step is approximately 0.15. (In table 6-4 the numbers have been rounded out to these values.) A step-by-step procedure for plotting a curve from a test made in this manner is as follows:

(1) The densities of the original step tablet are read and recorded as shown in the table. (These values are usually given by the manufacturer.)

(2) The densities obtained in the test strip are read and recorded in a column beside the densities of the original, also shown in table 6-3.

(3) A graph sheet having 20 squares to the inch is marked off in increments of 0.20 density units to the half inch, starting with 0 in the lower right-hand corner and moving to the left along the base line (horizontal axis) and upward along the right side (vertical axis).

(4) The densities of the original step tablet are then located across the base line with step 1 located near the right end and step 21 located near the left end of the line (considering step 1 to be the step having the least density).

(5) The density of each step of the test is then plotted by placing a dot on the graph opposite its value

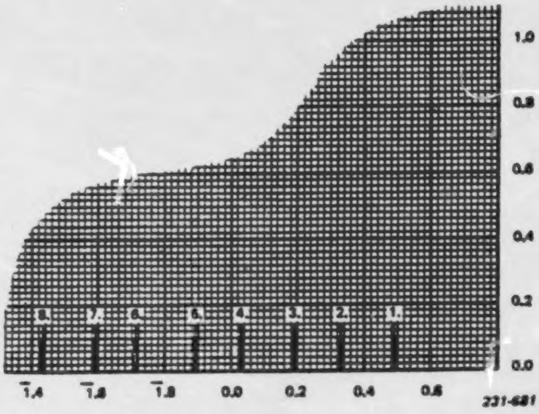

Figure 6-11. Plotting Log Es of the 21 steps (8 steps shown).

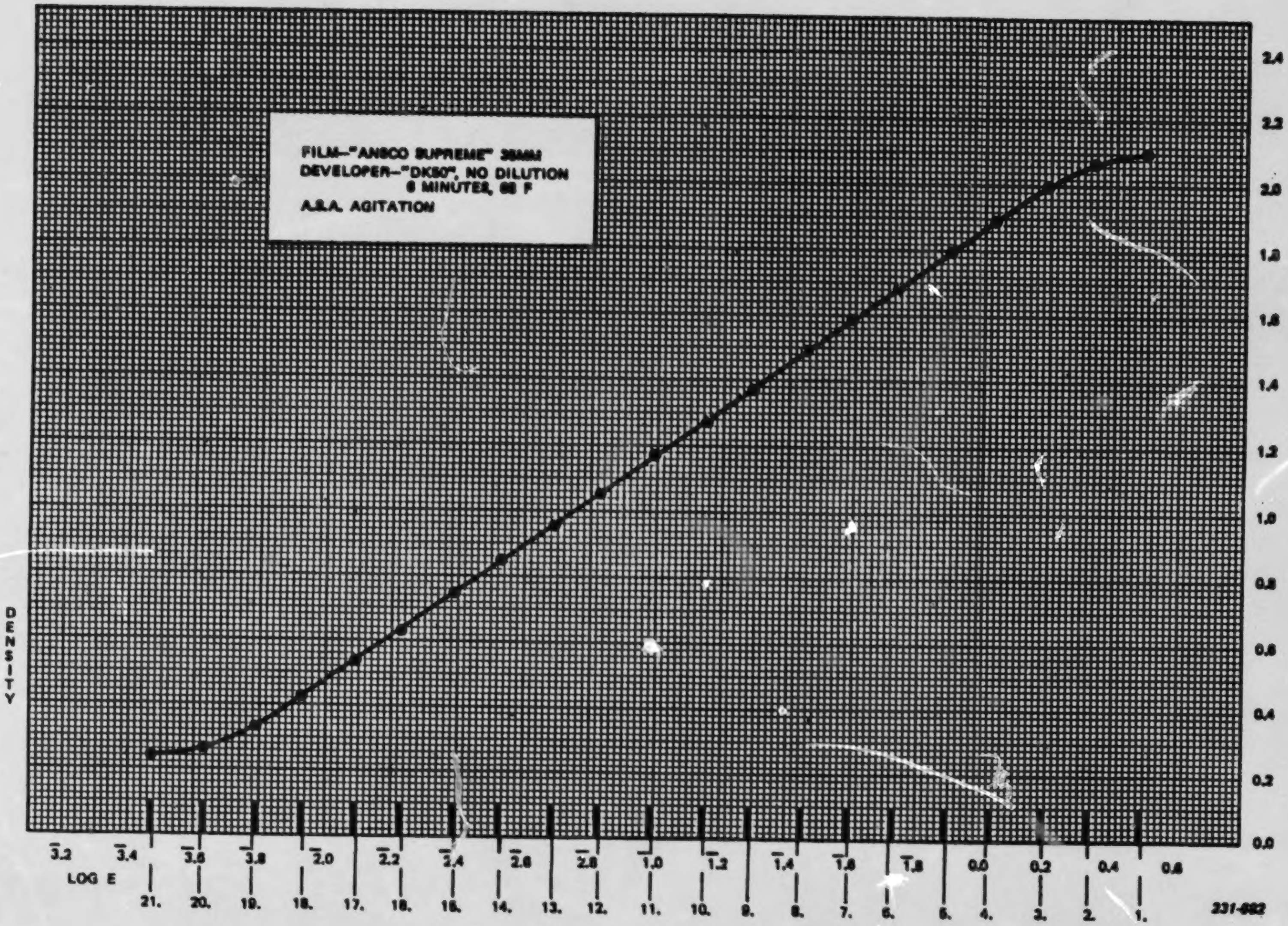

Figure 6-12. Completed characteristic curve.

TABLE 6-4

DENSITY OF ORIGINAL IS DENSITY OF TEST

Step Number	*Density of Original*	*Density of Test*
1	0.05	2.15
2	0.20	2.12
3	0.35	2.06
4	0.50	2.00
5	0.65	1.92
6	0.80	1.82
7	0.95	1.70
8	1.10	1.55
9	1.25	1.40
10	1.40	1.25
11	1.55	1.10
12	1.70	0.95
13	1.85	0.80
14	2.00	0.65
15	2.15	0.50
16	2.30	0.37
17	2.45	0.27
18	2.60	0.20
19	2.75	0.15
20	2.90	0.13
21	3.05	0.10

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on the vertical axis and directly above its corresponding step on the horizontal axis. This is continued until all 21 steps are plotted. (Step 1 of a negative test will be the densest step.)

(6) The dots shown in figure 6-13 may then be connected, using a straightedge and French curve, and the result will be a characteristic curve.

Labeling graphs. Since all characteristic curves are similar in appearance, every graph should be labeled with all pertinent information. Information which is not recorded on the graph may be lost or forgotten, and the graph becomes useless. Items of information on the graph should include the following: (See fig. 6-14.)

- Labeling the vertical axis "Density of Test."
- Labeling the horizontal axis "Log E" or "Density of Original," depending on the type of graph being plotted.
- The kind of material being tested.
- The developer and development used (time, temperature, dilution, and agitation).
- The gamma (γ) obtained. (You will learn how to determine gamma in a subsequent section.)

Analyzing Characteristic Curves. The main function of sensitometry is to measure, record, and represent graphically the reaction of light-sensitive emulsions to varying conditions of exposure and development to analyze and interpret results. Thus, it is possible to determine the effective speed of the emulsion, its contrast, and its latitude and useful exposure range. Also, the analysis of sensitometric curves provides the basis from which all sensitometric determinations emerge. Figure 6-14 illustrates a typical characteristic curve showing the various parts and their names.

Horizontal axis. A logarithmic scale of exposures is used for the horizontal axis because it gives correct representation of exposure changes.

Vertical axis. A logarithmic scale is used for the vertical axis because it correctly represents the amount of silver formed in the negative. Remember that density is the log of opacity. Theory indicates and measurement proves that density is directly proportional to the amount of absorbing material that is present in a given area.

Notice in figure 6-14 that the first two steps show a slight and equal amount of density. This indicates that this area of the film has not been affected by the light, and the density is due to the emulsion base and to the base fog which is present to a certain extent in all emulsions. On the third step, a slight increase in density is shown.

This is called the threshold and indicates the least amount of light that is required to produce a density which is perceptible. Exposures in this portion of the curve lack shadow detail.

Toe section. The threshold is the beginning of the toe portion of the curve. The toe is a concave, rising portion that gradually increases in density. This section is defined as a region of unequal rise because density does not increase equally for an equal increase in exposure.

Any subject tones exposed here will be reproduced with small, unequal density differences. These differences increase toward the right in the toe. At one time it was felt that this region of the curve was to be avoided. It is now known that satisfactory exposures can be made with the shadow portion of the subject falling not too far down in the toe area.

Straight-line portion. Farther to the right is a section of the curve that appears to approximate a straight line. (In many cases, there is no well-defined straight line.) This part of the curve has a constant slope, and in addition, the slope here is greater than in any other part of the curve.

The straight-line portion indicates that there is a corresponding and equal increase in density for equal exposure increases. This is the most important part of the curve because it represents the area of proportional brightness representation or correct exposure. Exposures arranged so that the subject tones fall on the straight line will produce constant maximum density differences.

Inertia point. When the straight line portion of the curve is extended to intersect a line extended from base plus fog, the point of intersection is called the inertia point. This point is sometimes used to measure emulsion speed or gamma.

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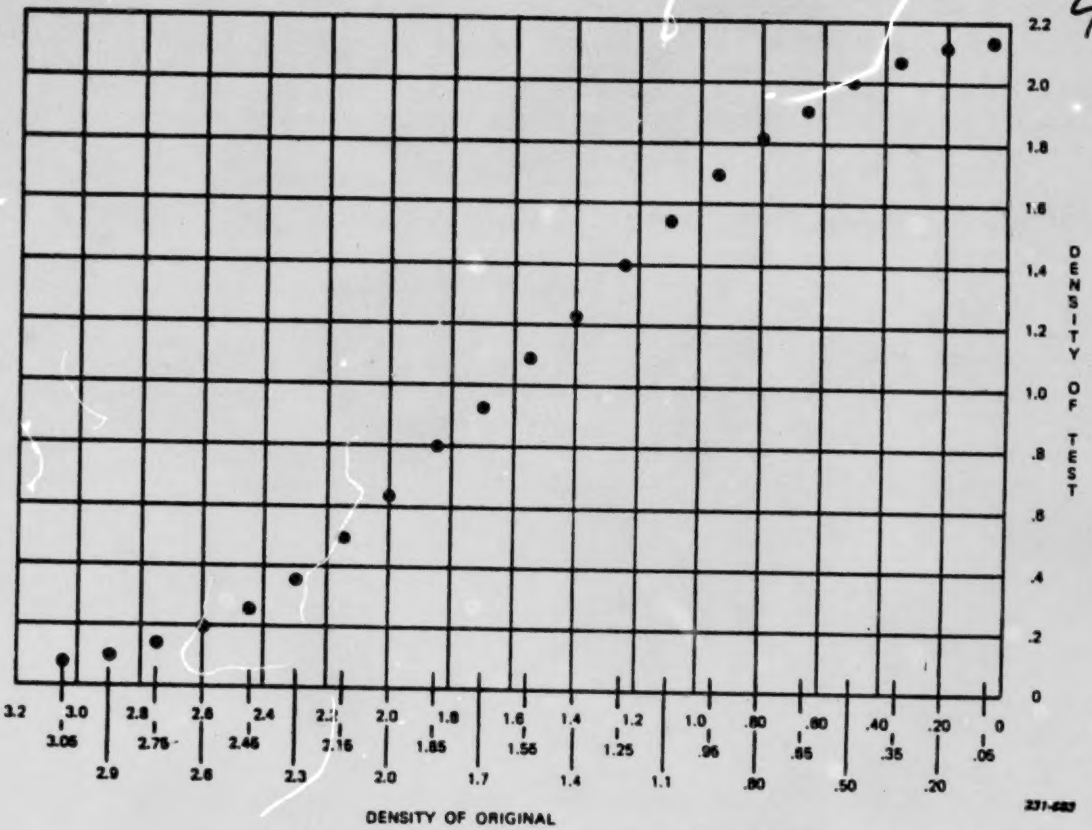

Figure 6-13. Density-density characteristic curve.

Shoulder. The upper portion of the curve is a convex, curved line, gradually decreasing in slope, called the shoulder. This again is an area where equal changes in exposure do not produce equal differences in density. Tones of the subject falling very far up in this area will be blocked; that is, reproduced with densities too heavy for printing for maximum detail. For normal exposures, bright highlight tones of the subject tend to be reproduced in the shoulder portion of the curve.

Density Differences. The vertical axis represents the densities in the negative. It shows the way in which the tones of the subject are reproduced by the negative material. Whether the general density level is thin, moderate, or heavy is of minor importance. What does matter is the difference between the tones. Of course, you should consider the detail that can be seen in a negative (whether the shadows are flat or full of detail and whether or not the highlights are blocked up.) This is what is meant in sensitometry by the term "density differences."

Density differences depend in part on the log E differences with which the process started. If the subject has many widely separated tones, large density differences are to be expected in the negative. Conversely, if the subject consisted of tones all nearly alike, the negative could hardly be expected to contain much variation in tone.

The negative quality depends on density differences in the negative. These density differences must be related to the log E differences which produce them; that is, density differences in the negative must be considered in their relationship with the tones in the subject.

The density differences in a negative can be partially controlled by placing the exposures corresponding to the subject tones in the right portion of the characteristic curve. This is done by correct adjustment of the camera settings, provided that the range of tones in the subject is not too great.

Emulsion Latitude. The latitude of an emulsion is the exposure range over which a proportional relationship between density differences and log E differences is obtained. In other words, it is simply the range of exposures covered by the straight-line portion of the characteristic curve.

The latitude of an emulsion, therefore, determines the brightness range of the subject which may be proportionally reproduced. Latitude may be expressed either as the difference in log E values between the

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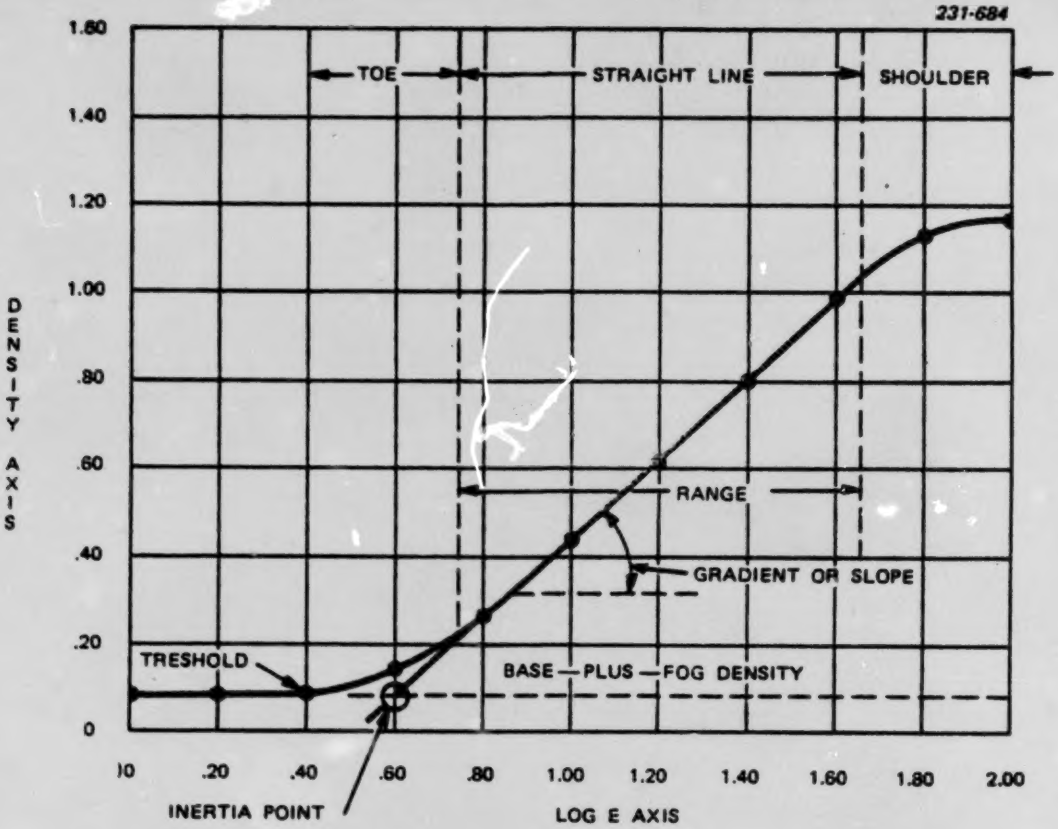


Figure 6-14. Characteristic curve.

extremities of the straight line or as the exposure ratio between these same two points.

The latitude of negative materials varies, according to the purpose for which they were designed, from 1 to 400 or more for a general-purpose panchromatic film to perhaps 1 to 20 or even less for process films. For any given emulsion, the latitude varies according to the gamma and becomes less as the gamma increases.

Useful Exposure Range. The useful exposure range includes parts of both extremities as well as the straight-line portion of the curve without sacrifice of quality of tone reproduction.

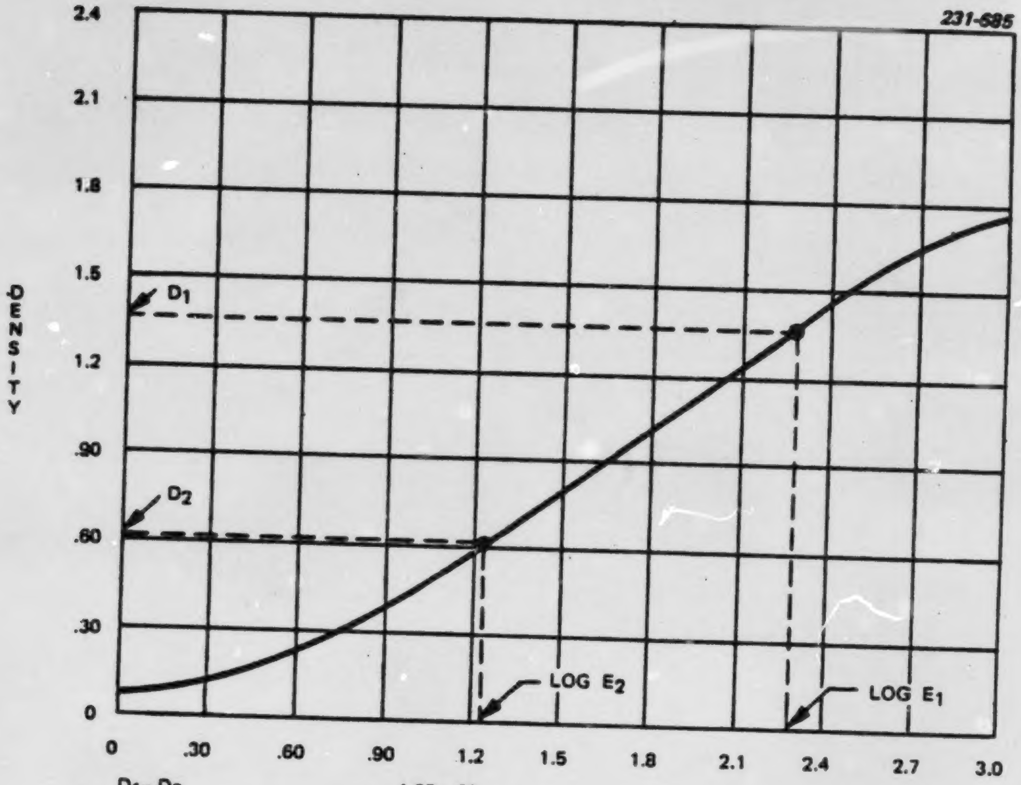
The lower limit of the useful exposure range is the point on the characteristic curve where the slope is 0.3 of the average slope for a log E range of 1.5. The upper limit of the range has not been fixed definitely but is generally taken to be at the point on the shoulder of the curve where the fractional slope is also 0.3. In practice, many photographers use a much lower upper limit because of the high densities involved.

Exposure Latitude. Exposure latitude is the tolerance that is allowable in camera exposure for a given scene. If, for example, the film latitude is 1 to 400 and the scene has a luminance range of 1 to 40, the exposure latitude is 10. The minimum exposure for the scene could be multiplied by 10, and the luminance would still fall within the latitude of the film. Exposure latitude is greater if the useful exposure range of the film is used, since portions of the toe or shoulder may be included along with the straight-line portion of the curve.

Gamma. In technical terms, gamma (signified by the Greek letter γ) is a sensitometric quantity standing for the slope, or gradient, of the straight-line portion of the characteristic curve of photographic emulsions. It is commonly interpreted as a measure of the contrast reproduced in a negative image; that is, the ratio of negative contrast to original subject contrast for a given range of tonal values.

Therefore, one of the primary uses of gamma is as a yardstick, or measuring device, for determining the degree of development of photographic materials, since change in development varies contrast or the slope of the curve. (Exposure changes, as previously explained, shift the position of the points right or left on the log E axis without altering the slope of the curve.)

Thus, the tendency is for exposure to control the



$\gamma = \frac{D_1 - D_2}{\text{LOG } E_1 - \text{LOG } E_2}$ OR $\gamma = \frac{1.35 - .60}{2.30 - 1.25}$ THEREFORE: $\gamma = \frac{.75}{1.05}$ OR $\gamma = .71^{+}$

Figure 6-15. Basic method of gamma calculation.

density and for development to control the contrast of the image reproduced. Remember the expression, "Expose for density—develop for contrast."

Mathematically, gamma is defined, for example, like the slope of a road. It is the ratio of the height gained to the distance traveled in a horizontal direction. In determining gamma, the height is density (D), and the horizontal base is the log of exposure (log E).

Materials capable of producing widely different gamma values are available. Normal photographic subjects call for films with a gamma value around 1.0, varying from 0.6 to 1.5. Such an emulsion will record the wide range of tones that are present in outdoor scenes. In practice, each of the main groups of negative materials has its own individual characteristics. Gamma is useful to the photographer because it tells him how his photographic material will respond to changes in exposure and processing.

Defining gamma. A definition of gamma may be gained from the foregoing discussion. You can see that gamma may be defined in different terms. Some useful definitions include the following:

(1) Gamma is the numerical measure of the contrast reproduced in a negative image.

(2) Gamma is a numerical measure of the degree of development (for a given material).

(3) Technically, gamma is the slope of the straight-line portion of the characteristic curve.

(4) Mathematically it may be defined as follows:

(a) The ratio of the height gained (difference in any two densities on the straight-line part of the curve) to the horizontal difference between the log E's that produced the two densities.

(b) The tangent of the angle formed by the intersection of an extension of the straight-line portion of the curve and the horizontal axis.

Gamma determination. Once the curve has been plotted, gamma can be determined by several methods. Four methods are presented here.

(1) Basic method—this method, shown in figure 6-15, involves the ratio between densities and the exposures which produced them. Any two points on the straight line are chosen. (More reliability tends to result if the points are widely separated.) Gamma is the result of dividing the change, or difference in density,

by the difference in log E between the two points. The formula is:

$$\text{Gamma} = \frac{\Delta D}{\Delta \log E} = \frac{D_1 - D_2}{\log E_1 - \log E_2}$$

Δ (delta) is the Greek symbol for change or difference.

(2) Graphic method—from the point where an extension of the straight line portion crosses the horizontal axis, move to the right a distance of 1.00. Construct a dotted vertical line to intersect the straight line portion of the curve. Gamma may then be read directly from the values labeled on the vertical axis at that point.

(3) Quick method—use a gamma meter (a transparent overlay). The arrow point is placed on the straight-line portion of the curve with the base line of the meter parallel to the log E axis. Gamma is indicated where the straight line intersects the scale.

(4) Simplified method—select a point on the straight-line portion of the characteristic curve at one of the minimum densities. From this point, count over 50 spaces in a horizontal direction. Now count the number of spaces in a vertical direction until you intersect the straight-line portion of the characteristic curve. Multiply this figure by 2 and divide by 100. For example, if you had counted up 40 spaces, the calculation would be as follows:

$$\frac{2 \times 40}{100} = 0.80 = 0.8 \text{ gamma}$$

or

$$\frac{40}{50} = \frac{4}{5} = 0.8 \text{ gamma}$$

Significance of Gamma. Gamma is often referred to as "development contrast," but this is just partly true. Since gamma is concerned solely with the straight line portion of the curve, it can only indicate the contrast of that portion. It is a useful measure of degree of development and is a valuable processing control. An increase in gamma indicates an increase in development, all other parameters being unchanged. An increase in time, temperature, agitation, or developer activity results in increased gamma; and a decrease in any of these factors results in decreased gamma. A moderately energetic developer can produce high gamma if the time, temperature, or both are stepped up. Moreover, the reverse is true. A high energy developer can be made to produce low gamma if the other factors are held back.

It is important to remember that gamma relates only to development—not to exposure. A photographic negative developed to a predetermined gamma will possess that gamma regardless of the exposure. The densities in the negative which correspond to straight line densities in the density vs density curve will have the same density differences. Of course, sensitometric curves made with different exposures would occupy correspondingly different positions on a graph.

As mentioned earlier, increasing development increases gamma, but only to a certain point (gamma-infinity). Ultimately, extending development has no effect on the slope of the curve, and gamma does not change. When this happens, the effect of further development is seen chiefly in the fog level. The point at which gamma-infinity, as it is called, occurs varies mainly with the emulsion; and this provides valuable information concerning films. However, since it is also affected to some degree by the developer used, gamma-infinity is usually considered in terms of film developer combinations. Typical infinity values for some different types of emulsions when processed in the developers normally used for them are as follows:

a. High-speed portrait film	1.2
b. High-speed press films	1.7
c. Commercial films	2.0
d. Process films	3.0

Exercises (666):

1. The vertical and horizontal axes of a characteristic curve are used to chart what values?

2. How is the log of exposure for a particular step calculated?

3. Each axis of a characteristic curve is marked off in units of what value?

4. In a density vs density curve, each axis represents what values?

5. What does the toe section represent?

6. What is the threshold?

7. What does the straight line portion of a curve represent?

8. What part of the subject will be recorded in the shoulder of the curve?

9. Define emulsion latitude.

10. Useful exposure ranges over what parts of the characteristic curve?

11. What is the technical definition of gamma?

12. Describe the graphic method of finding gamma.

13. Gamma is primarily affected by what part of the photographic process?

14. Extreme overdevelopment will cause an increase in what level?

667. State the principles and procedures related to the replenishment of developers.

Effects Resulting From Use of Developers. With use, the activity of the developing solution changes. The used developer becomes slower in its reaction; and as a result, a longer development time is needed to achieve the same result. There is therefore an effective loss of film speed as the developer deteriorates. The change in the activity of the used developing solution is the result of chemical changes that take place within the solution.

Chemical changes in the developer are the result of the following:

- Chemical reaction of the developing solution with the silver halides of the emulsion.
- Action of the air upon the solution (oxidation).
- Loss of solution through carryover to the following tank.
- Dilution of the developer (when a predevelopment bath is used). The most significant of the chemical changes are those caused by the chemical reaction of the developing solution with the silver halides and the air.

As the developing solution reacts with the silver halides, metallic silver is formed in the emulsion and complex reaction byproducts are formed in the developing solution. The most significant of these reaction byproducts are the bromides and iodides. The reason they are significant is that they have a restraining effect on the developing agent. The developer-silver-halide reaction tends to cause the pH of the developer to drop.

The reaction of the developing solution with the surrounding air creates oxidation byproducts which are not useful but which cannot be avoided. Aerial oxidation of the developing solution tends to raise the pH of the developing solution. The reason the pH tends to rise is that sulfonates are formed as a result of the oxidation process, and these sulfonates are alkaline.

In addition to the depletion of the developing agents, there is a simultaneous depletion of the alkali and sulfite. However, the restraining action of the iodides and the bromides which accumulate in the developing solution is more significant than the reduction of developing agent, alkali, and sulfite.

Detection of Developer Deterioration. You cannot detect the degree of exhaustion of the developing solution just by measureing its pH. The pH is lowered by reaction between the developing agents and the silver halides, but it is raised by the reaction between the developing agents and the air. Nor can specific gravity measurement by itself provide you with much useful information about the used developing solution.

You can check the deterioration of the developing solution through detailed solution analysis. In such a procedure, you must analyze the solution for Metol, hydroquinone, bromide, sulfite, and carbonate content. Through this type of analysis, you get exacting information about the degree of deterioration.

If neither pH measurement nor specific gravity measurement can give a concrete indication of solution deterioration, and complete analysis of the developing solution is not practical, how can you detect deterioration of the developing solution? One of the easiest methods for doing this is to monitor the results that are produced by the solution. Use sensitometric methods and use them frequently.

If you process totally standardized sensitometric control strips when the solution is fresh and when it is being used, you will be able to spot any significant changes in the solution.

If you have serious doubts about the quality of a given solution, you can always process a standardized control strip by itself to verify the adequacy of the solution. This will avoid possible damage to critical film.

To determine solution performance, you compare the results of characteristic curves prepared from the tests made in used solution with the characteristic curves prepared when the solution was fresh. Changes in the characteristic curves are normally used as the basis for determining when the developing solution is no longer adequate.

Developer Replenisher. Not only must the replenisher solution add chemicals which have been used up in the processing of sensitized materials, but the replenisher must also lower the concentration of the iodides and bromides which have accumulated in the used solution. Satisfactory replenisher formulas depend upon the processing conditions used, the type of solution, and the kind of photographic material being processed. Storage conditions, frequency of use of the developer, the amount and type of agitation, aerial oxidation, how much the sensitized material was exposed, and the degree of development also figure into the compounding of a satisfactory replenisher.

The constituents normally found in the replenisher solution are water, reducing agents (example, metol), sodium sulfite, and an alkali (example, sodium carbonate). The replenisher contains no bromide; in fact, as previously stated, it is normally designed to add a sufficient amount of solution to the existing developer to dilute the accumulated bromides and iodides to a suitable level. Most developer formulas have accompanying replenisher formulas so that you do not have to determine the exact amounts of each of the chemicals that are to be added. However, you should remember that an emergency replenisher solution can usually be compounded by mixing a modified solution of the developer itself, omitting the bromide. Solutions prepared with such a replenisher solution cannot be expected to maintain the consistency of results that you would get if you used a properly compounded replenisher. There will, however, be a significant extension of the useful life of the developing solution.

NOTE: There are packaged replenishers which are simple and easy to use and therefore do not call for compounding of a formula. In fact, many color kits come with replenishers.

Methods of Developer Replenishment. Replenishment is normally done in one of two ways:

a. By intermittently adding given amounts of replenisher as specific amounts of material have been processed in the solution. Normally, the manufacturer indicates how many milliliters of replenisher to add per square foot of processed film. It is therefore necessary to keep a running total of how many sheets or rolls of film have been processed. Through calculation you can determine how many rolls or sheets to the square foot.

This method of replenishment is normally used in hand processing. The correct procedure is to take out an adequate amount of solution from the tank. Then you pour in the correct amount of replenishment. Finally you bring the solution up to level with the old solution that you carried out in step one. This prevents the tanks from overflowing, which will happen if you simply pour in the replenishment solution.

b. By continually adding replenisher at a calculated rate of flow, when processing is being done continuously. This is used in machine processing and is normally done through a pumping system which is controlled by a metering system.

NOTE: In certain cases the developer solution is not replenished, but the processing time is gradually increased as more and more sensitized material is handled.

End point for Developer Replenishment. The process of replenishment, even with the application of precise analytical procedures, cannot be continued indefinitely. At some point the used solution must be discarded, and processing must be resumed with fresh solution. Impurities tend to collect in the used developing solution. These impurities are reduced silver sludge, calcium sulfite sludge, gelatin, degradation products of gelatin, dust, colored oxidation products (which tend to stain the gelatin), etc. It should be standard practice for your laboratory to dump the solution when there is a possibility that the accumulated impurities in the used developing solution may cause image deterioration.

Exercises (667):

1. List four factors which cause the deterioration of a developer.

2. What significant byproducts are formed during development? What effect do they have on developer performance?

3. What testing method is probably best suited for indicating the changes of a developer solution?

4. What are the normal parts of a developer replenisher?

5. Rate of replenishment is normally based on what factor?

6. When replenishing a tank, why must you first remove some of the solution?

7. When do you reach the end point of replenishment?

668. State the principles of procedures related to the replenishment of stop baths.

Replenishment of Stop Baths. The common acid stop bath is a simple acidic solution which neutralizes the alkali of the developing solution. By acidifying the developer carried over in the emulsion, the stop bath places the developing agents in an acidic environment and their activity becomes minimized. The secondary function of the stop bath is to minimize the carryover of alkaline developer into the acidic fixing bath, thereby prolonging the life of the fixing bath. Because of the reaction of the stop bath with the developer, exhaustion of the stop bath is inevitable. At times it is not feasible to replace the stop bath; and, in such cases, you must replenish it.

Effects resulting from use of stop baths. As the stop bath is used, the acid of the bath is neutralized by the carryover of alkaline developer into the stop bath solution. The reaction byproducts are insignificant, but the drop in acidity tends to make the stop bath ineffective.

Detection of stop-bath deterioration. Deterioration of a chrome-alum stop bath is accompanied by a color change from purple to a yellowish green. When this change occurs, the bath should be discarded immediately and replaced with fresh chrome-alum stop bath.

Detection of deterioration of the acetic acid stop bath is not as simple, since there is no visible change in the solution. The pH of the solution is the measure of its adequacy. For best results the pH of the acetic acid stop bath should be maintained between 4.0 and 5.0. You can measure the pH with a pH meter, but under average conditions you don't need a measurement that exact. Normally one of the common pH indicators will suffice. For example, you can measure the pH of the stop bath conveniently by using pH test paper. Briefly immerse the test paper in the stop bath and compare its color to the standards supplied with the paper. Since the color changes as the test paper dries, be sure you make the comparison immediately after the strip is removed from the solution.

Additives in the stop bath replenisher. You can replenish the stop bath by adding appropriate amounts of a strong solution of acetic acid. Calculate the strength of the solution so that you maintain a constant level of solution in the tank and yet have the correct amount of acid to bring the pH to the desired level.

End point for stop bath replenishment. The end point for replenishment of the acid stop bath occurs when there is a sufficient accumulation of foreign material in the bath to endanger the photographic image. Because of the relatively low cost of the stop bath, it is wise to change the bath any time you must shut down operations to replace the developing solution or the fixing solution. This change in the stop bath does not increase the shutdown time significantly, and it assures you that the stop bath is adequate.

Methods of stop bath replenishment. The replenishment of acid stop baths can be done intermittently or continuously, depending on which of the two methods is more convenient. When the stop bath is being used in conjunction with a continuous processing machine, continuous replenishment is usually used. One or two tests per day are usually sufficient to assure you that the solution is being maintained at the desired strength. If this frequency of testing indicates that the concentration of the hydrogen ion exceeds the acceptable limits, you should alter the replenishment rate until an acceptable range of pH is maintained by the replenishment system.

Exercises (688):

1. State the two functions of an acid stop bath.

2. As a stop bath is used, what takes place to make it ineffective?

3. What visible change takes place as a chrome-alum stop bath deteriorates?

4. At what pH levels should an acetic acid stop bath be maintained?

5. What additive is used to replenish an acetic acid stop bath?

6. What is the end point for replenishing an acid stop bath?

7. When would you use continuous stop bath replenishment?

669. List and explain the principles and procedures related to the replenishment of fixing baths.

Replenishment of Fixing Baths. You know that fixing baths tend to wear out. Satisfactory replenishment of fixing baths depends upon a great many things because of the complexity of the solution and the complexity of the changes which it undergoes during use.

Effects resulting from use of fixing baths. We have covered in general many of the things that take place in fixing baths as they are being used; now we shall be more specific.

Carryover is one of the problems encountered. Carryover of previous solutions into the fixing bath and carryover of the fixing bath into the wash cause some specific changes in the fixing bath activity. Carryover of the previous solutions into the fixing bath tends to dilute the chemical components of the fixing bath; the net effect is to increase the clearing time. But, in addition, if the preceding solution is a water bath, there is a significant dilution of the acidity of the fixing bath. on the other hand, if the preceding solution is a strongly acidic stop bath, the acidity of the fixing bath may be raised. The carryover of alkaline developer tends to neutralize the acid and to convert the bisulfite in the fixing bath to sulfite.

Carryover of the fixing bath into the wash depletes the silver halide solvent chemicals of the fixing bath, and this, in turn, increases the clearing time. Also, the fixing bath acidity is reduced because of the carryover of the fixing bath acid into the wash.

Chemical reaction of the fixing bath with the emulsion is a multifold action:

- Complex silver compounds called argentothiosulfates are formed. This reaction tends to use up the thiosulfate.
- Neutral salts are formed. In high concentrations these salts work as retardants. In low concentrations these same neutral salts work as accelerators.
- Iodide is liberated in the fixing bath. Not only does the iodide retard the action of the fixing bath on the silver halides, but it also has the effect of depressing the solubility of the bromide. The net effect is retardation of the clearing action.
- Exhaustion of the fixing bath is accompanied by exhaustion of the sulfite. The loss of sulfite is not too significant, since the other activities usually bring about deterioration of the fixing bath before the sulfite is exhausted.

Deterioration of fixing baths. Deterioration of the fixing bath usually comes about in stages. The first property of the fixing bath to change significantly is its acidity. After the acidity drops below the required level, there is a loss of hardening properties. Then clearing time increases; the clearing time increase is partially due to the exhaustion of the hypo, but primarily due to the concentration of the iodide. Ultimately the fixing bath forms complex thiosulfates which are insoluble and which cause the image to deteriorate after it has been washed and dried.

NOTE: When a chrome-alum fixing bath exceeds a pH of 6.5, a precipitate of chromium hydroxide forms on the surface of the emulsion.

A good guide to the degree of exhaustion of the common potassium-alum fixing bath is provided by the use of pH indicator papers, since the change in acidity is the first serious change in the fixing bath characteristics.

Additives in the fixing bath replenisher. The life of a potassium-alum fixing bath can be extended by the addition of a replenisher composed of a sufficient quantity of acid to bring the pH of the solution up to its normal level and a sufficient quantity of hardening agent to harden the emulsion satisfactorily. However, the extension of the life of the fixing bath is limited because of the accumulation of iodide and silver.

Bisulfite in the fixing bath can be regenerated by very cautious additions of dilute sulfuric acid. This is a very critical operation because any excess of acid will cause decomposition of the thiosulfate. This type of replenishment should be done only when you are well aware of the complications involved.

Boric acid is sometimes added to the fixing bath to extend its useful life.

Usually the replenishment of fixing baths (with the exception of minor extensions in their life) is not considered practical unless a silver recovery process can be used on the solution prior to replenishment.

End point for fixing bath replenishment. Regardless of the replenishment process used, the useful life of fixing bath is ultimately limited by the accumulation of the iodide in the bath. This is true even of fixing baths that have been regenerated through silver recovery and appropriate replenishment.

Methods of fixing bath replenishment. Since you may be using extremely large volumes of fixing bath, it may prove economical to apply a practical system of replenishment in conjunction with silver removal.

Essentially the silver removal process consists of immersing two electrodes in the used fixing bath and passing a current between the electrodes. The anodes are usually made of graphite, but the cathodes may be either graphite or stainless steel. As current is passed through the ionized fixing bath (which must be acidic), the sodium ions tend to migrate to the cathode. Argentothiosulfate ions tend to migrate toward the anode. The sodium atoms formed at the cathode react with neighboring ions in the solution (including the argentothiosulfate ions). The reaction liberates free silver if there is a sufficient concentration of the argentothiosulfate ions. However, if there is a shortage of argentothiosulfate ions, the sodium tends to react with the thiosulfate ions. The product, among other things, is sulfide ions. These sulfide ions then react with the argentothiosulfate ions to form silver sulfide. The silver sulfide discolors the fixing bath. (This particular action shows the importance of having the fixing bath sufficiently saturated with silver when regeneration by electrolysis is used.) Filtering the solution is necessary prior to and during the electrolysis. Note that unless there is a sufficient concentration of silver in the bath, removal of electrolytic silver is not practical. To assure an adequate supply of argentothiosulfate ions, the solution is usually stirred vigorously (so that high levels of current may be used). Another method of achieving a practical rate of silver recovery is to use a very large electrode surface.

Replenishment consists of discarding parts of the solution and replacing this discarded solution with properly compounded fresh fix-bath replenisher.

When large amounts of fixing bath are involved, it is worthwhile to recover the iodine. Iodine can be recovered from a used fixing bath by adding a 5-percent solution of thallous sulfate. The reaction with the fixing bath results in the precipitation of thallous iodide. Iodide can then be recovered by decomposition of the thallous iodide.

Exercises (669):

1. What is the effect of the two types of carryover on a fixing bath?
2. List the four chemical reactions that result from the interaction of the fixing bath with the emulsion.
3. Identify the four stages in the deterioration of a fixing bath.
4. To have an effective replenishment program, it should be in conjunction with what procedure?
5. What causes the end point of fixing bath replenishment?

6-10. Compute Analysis for Repeatability

Statistical control is important in mass-production photography because of the great deal of raw data that is produced in the act of controlling the photographic product. Through statistical control methods, you can reduce the raw data to meaningful data. By arranging, plotting, and analyzing the data, you can create norms and limits for the process. After you have done this, you then make continuing comparisons with the standards you have set to determine how well the process is operating.

In this section we will discuss the use of control charts that help you to keep track of your processing graphically.

670. Complete statements on the use of control charts.

Variability. The term "variability" signifies change, uncertainty, and deviation. The term "variance" is a mathematical expression used to describe the measurement of variability. Variability is characteristic of all things in nature as well as all man-made products and man-devised processes. No two natural objects, man-made products, or processes are exactly alike. Some differences, however slight, always exist. Often the differences are so small that they can only be detected by extremely sensitive measuring devices, but the differences exist nevertheless.

Since you work in a field which is highly technical, you are forced to recognize the existence and the importance of variability. In your job you need to measure variability, to record variability, and when possible to control variability. Most of the time you do this by employing a sampling technique (based on the laws of probability), by graphing and charting the data samples, by analyzing the graphs and charts, by assigning numerical values to the deviations that occur, and by controlling future operations through application of the knowledge gained.

Control Charts. Although nothing in life is constant, extensive observation shows the existence of what might be called a constant cause system. This suggests, that while a representative process produces results that vary, they fall within certain limits most of the time. The same percentage of results will fall within these limits as long as the constant cause system

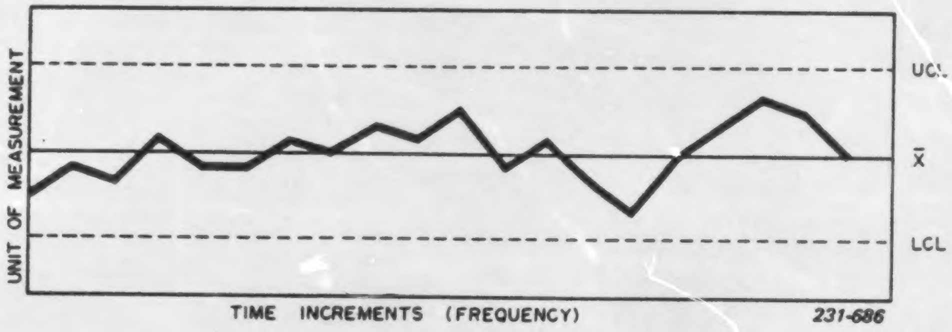


Figure 6-16. Typical control chart.

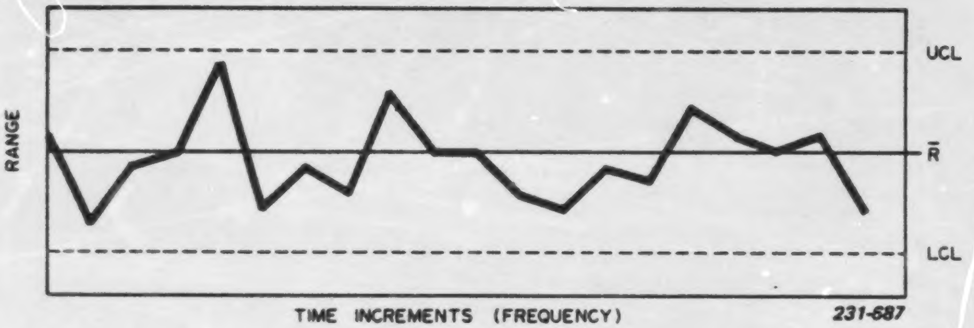


Figure 6-17. Typical range chart.

continues to operate; we can therefore consider that we have a stable distribution of results. When a process produces results that display stability, we can say that it is in statistical control. The control chart is our means of knowing whether or not our process is in statistical control.

The control chart is a progressive line graph such as is shown in figure 6-16. It consists of two axes and three lines. The first, or horizontal, axis may be marked off in periods of time, frequency, or in some other way. The vertical axis is marked off in whatever unit that you may be using in the measurement of the sample. It may be gamma, pH, density, or another unit. The center line of the chart is the mean, or process average, and is the line upon which you wish to base your measurements. The two other lines, one above and one below the average, are the process limits. These may be based, as they usually are, on the standard deviation, or they may be based on certain product specifications. In the figure the horizontal axis is shown as frequency, or time increments. Generally, control charts are marked off into days of operation, but any time or frequency unit might be used, depending upon your operation and the amount of control you need to employ. The vertical axis is usually marked off in some unit of measurement. In a process control chart, the unit might be "gamma." The upper dashed line, labeled "UCL" is the upper control limit, and the lower dashed line, labeled "LCL," is the lower control limit. The center line, labeled "$\overline{X}$," shows the process average.

$\overline{X}$ and $\overline{R}$ control charts. Figure 6-16 illustrates one of the two basic types of control charts. Since its center line delineates the process average (the symbol X signifies individual observations, and the bar over the X indicates that the individual values are averaged), this chart is called a chart of averages, or an $\overline{X}$ (pronounced "X-bar") chart. The second basic control chart type is called an $\overline{R}$ (pronounced "R-bar") chart, or range chart, and is based on the ranges of values of the observed individuals (see fig. 6-17).

To learn how these charts are used, let's assume that you are keeping control charts on pH determinations of samples taken from a film processing machine. Let's say that you take 5 samples a day. After 6 days you have accumulated the data shown in table 6-5. You might start a range chart after the first day and plot on it the range or difference between the high and low readings for the day. At the end of the second day you would plot a point corresponding to that day's range, and connect the two plots with a straight line. You would continue to plot and connect points for as long as you keep the range chart. After 6 days your range chart would look like figure 6-18. At the end of the sixth day you calculate that the $\overline{R}$ is 1.1 and you draw the appropriate line through the chart; but, as yet, you are unable to establish any meaningful control limits. Your next step is to construct a chart of averages and to calculate control limits for both. Figure 6-19 illustrates a chart of averages, using the data in table 6-5.

Note that your plots reflect the average pH reading for each day; therefore, the center line of your chart gives you the average of averages and is labeled $\overline{\overline{X}}$ (called X-double bar, or X-bar-bar) to indicate that fact.

Establishing upper and lower control limits. Control limits can be established through your own experience or standards set by the manufacturer of the chemistry,

TABLE 6-5
pH READINGS OF A DEVELOPER SOLUTION IN A FILM PROCESSING MACHINE

231-706

Day	1	2	3	4	5	Range	$\overline{X}$
1	10.9	10.4	9.7	10.6	10.2	1.2	10.36
2	10.3	9.5	9.2	9.8	10.7	1.5	9.90
3	11.4	10.5	10.7	9.6	10.2	1.8	10.48
4	10.7	10.1	10.5	10.5	10.2	.6	10.40
5	10.2	10.3	9.5	9.8	10.1	.8	9.98
6	9.7	9.9	10.0	10.4	10.3	.7	10.06
						$6\overline{)6.6}$	$\overline{)61.18}$
						1.1=R⁻	10.20=$\overline{\overline{X}}$

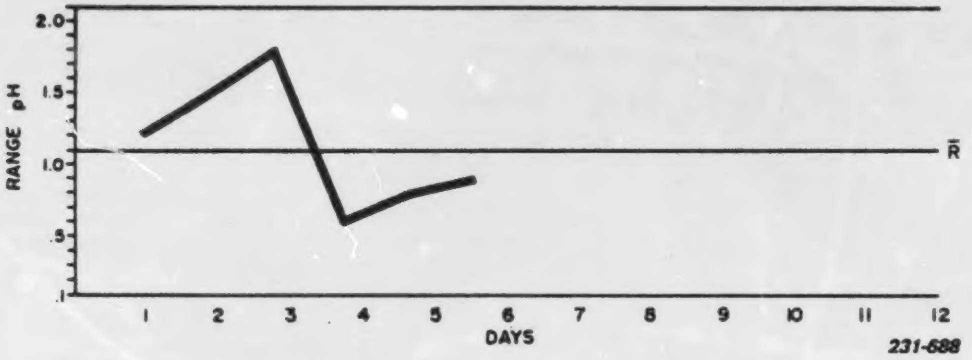


Figure 6-18. Range chart from the data in table 6-4.

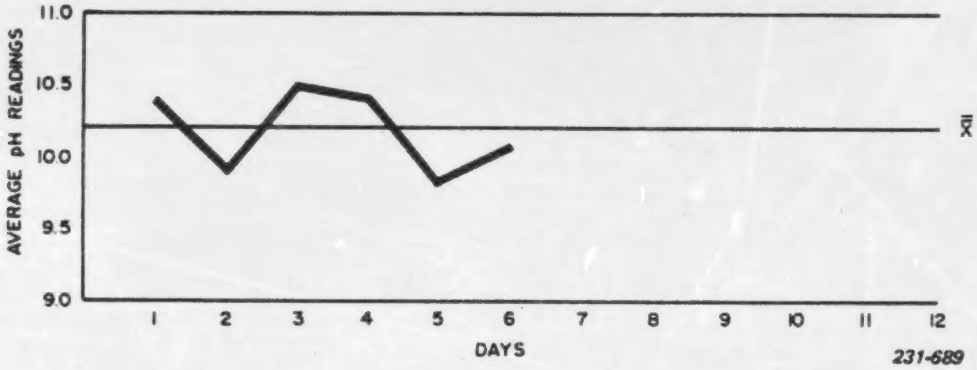


Figure 6-19. $\overline{X}$ chart from the date in table 6-4.

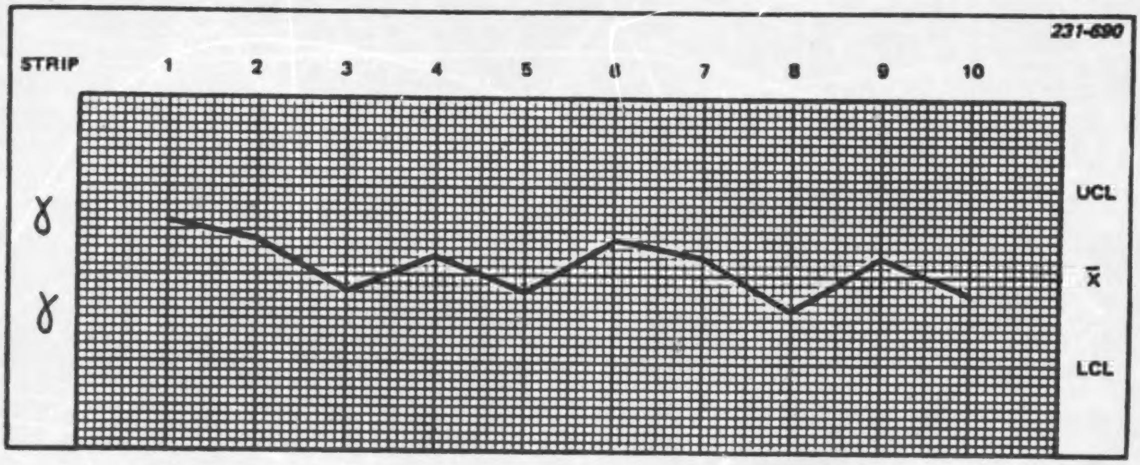


Figure 6-20. Normal control chart.

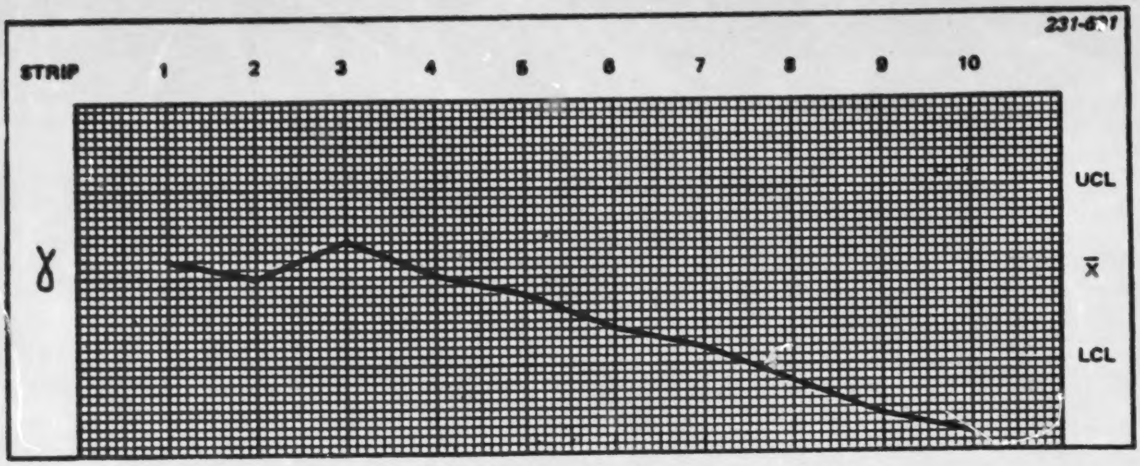


Figure 6-21. Trend of control chart.

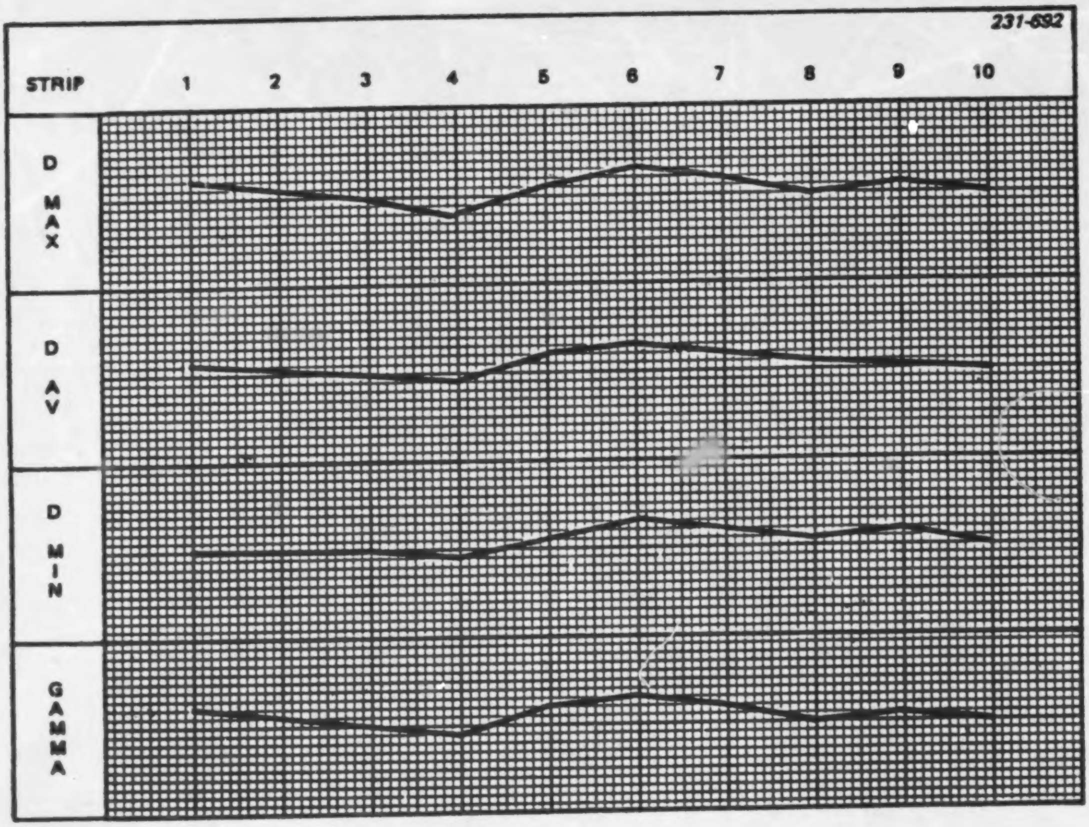
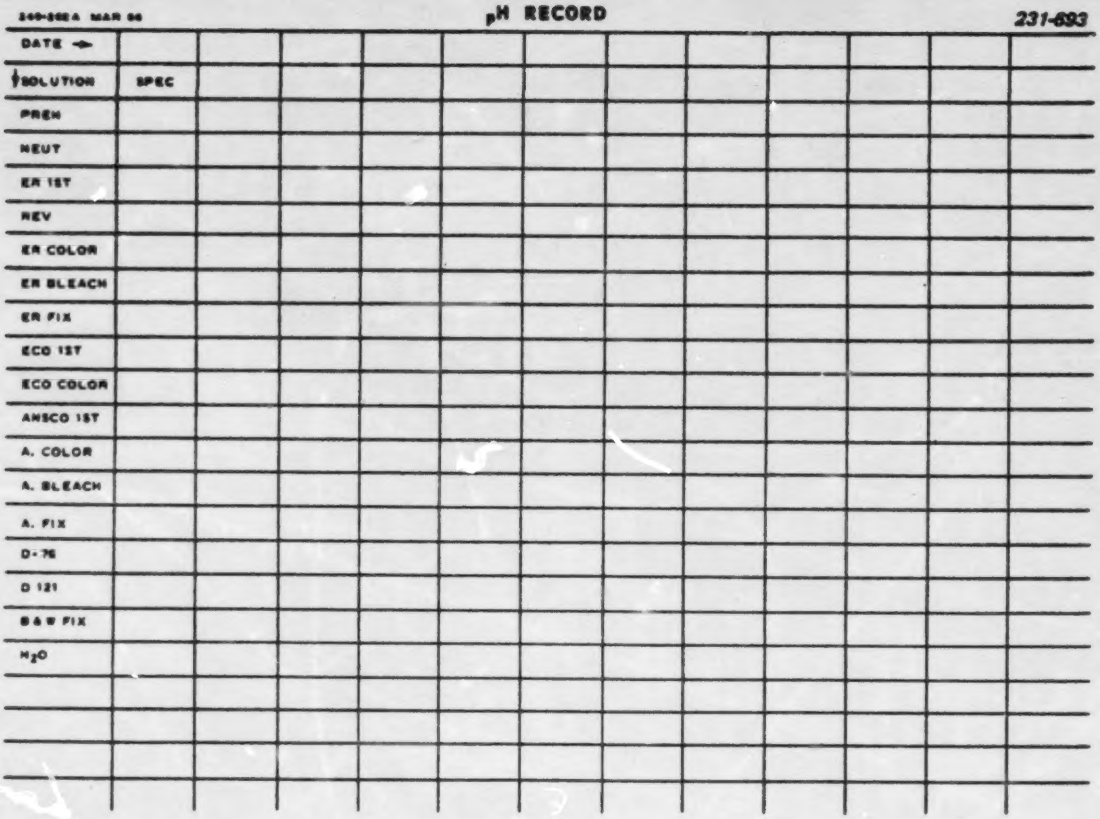


Figure 6-22. Replenishment.



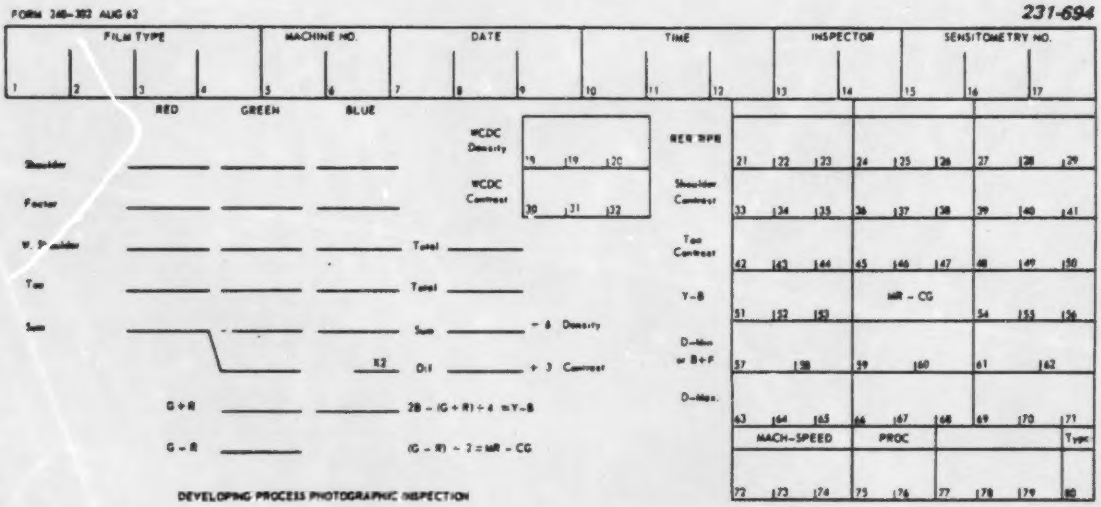
240-282A MAR 66

pH RECORD

231-693

DATE →												
↓SOLUTION	SPEC											
PREH												
NEUT												
ER 1ST												
REV												
ER COLOR												
ER BLEACH												
ER FIX												
ECO 1ST												
ECO COLOR												
ANSCO 1ST												
A. COLOR												
A. BLEACH												
A. FIX												
D-76												
D 121												
B & W FIX												
H_2O												

Figure 6-23. Typical pH record chart.



FORM 240-302 AUG 62

231-694

FILM TYPE	MACHINE NO.	DATE	TIME	INSPECTOR	SENSITOMETRY NO.
1 2 3 4	5 6	7 8 9	10 11 12	13 14	15 16 17

	RED	GREEN	BLUE		
Shoulder	______	______	______		
Factor	______	______	______		
W. Shoulder	______	______	______	Total	______
Toe	______	______	______	Total	______
Sum	______	______	______	Sum	______ ÷ 6 Density
		______	X2	Dif	______ ÷ 3 Contrast
	G + R	______	______	2B − (G + R) ÷ 4 = Y−B	
	G − R	______		(G − R) ÷ 2 = MR − CG	

WCDC Density	18 19 20
WCDC Contrast	30 31 32

RER RPE	21 22 23	24 25 26	27 28 29
Shoulder Contrast	33 34 35	36 37 38	39 40 41
Toe Contrast	42 43 44	45 46 47	48 49 50
Y−B	51 52 53	MR − CG	54 55 56
D-Min or B+F	57 58	59 60	61 62
D-Max.	63 64 65	66 67 68	69 70 71

MACH-SPEED	PROC		Type
72 73 74	75 76	77 78 79	80

DEVELOPING PROCESS PHOTOGRAPHIC INSPECTION

Figure 6-24. Typical process inspection slip.

etc. These limits are then drawn on your chart as shown in figure 6-16. If your plottings go above or below these limits, it is a warning to you that your processing may be off, and you should conduct the necessary tests. In fact, if you plot 5 to 7 points in the same direction, such a trend should be warning enough even though it does not go out of limits.

For your reference, check figures 6-20 through 6-22 which show a normal chart, a trend, and one showing the effects of replenishment.

Interpreting control charts. Now let us analyze our average and range charts and obtain the information contained in them. First, let us analyze them separately and then in conjunction with each other. Looking first at the range chart (fig. 6-18), you can see that the operation is apparently within good control. If this were a new process that had just been started, it would appear that for the first 3 days the process was covering a large range and was not under very good control but that on the fourth day some corrective action had been taken, bringing the range nearer to the desired point. If the range were to continue at this lower average point, it might be desireable at some future date to lower the process average to conform more closely to the actual process average range.

When analyzing the average chart (fig. 6-19), you will note an entirely different pattern. All points are in good control, but there is a definite unevenness to their movements. It is normal in any random process that the points continuously vary above and below the average line. On the first day the average pH reading was above the process average. On the second day it was below the average, and on the third day it had moved up again. After this, the plots seem to follow the process average a little more closely, although it would be necessary to obtain more readings to draw a definite conclusion here. In comparing the two charts, more readings should be obtained before making definite conclusions; however, it would appear that the process for the first 3 days was erratic and not very stable, but that at the end of this period a tendency was beginning to develop, indicating an improving condition.

Application of control charts. In an Air Force laboratory where quality control is practiced, control charts are used in 3 major areas. These are chemistry, sensitometry, and final product quality. In the chemistry section, control charts are used to monitor the quality of fresh mixes and to record the analytical data pertinent to a process run. In all probability your laboratory uses various forms for convenience in accumulating data to be plotted on control charts. Figure 6-23 is a pH record chart typical of those in current use. You will have, or should construct, similar record charts for all of the analyses you conduct, including pH and specific gravity measurements of processing solutions taken periodically during the run.

Sensitometric data is usually entered on a process inspection slip similar to that shown in figure 6-24 and later transferred to a control chart. The control charts are usually inspected hourly in large-scale production laboratories. If the process is in control, nothing is done to change it. But at the first sign that the process is going out of control, an investigation is started immediately. Process control charts are posted near the machine they record and are generally large enough so that the information plotted on them is visible from some distance.

These are just a few of the record slips and control charts that you might use during your career. It is impossible to cover every slip and chart in a CDC of this sort; however, if you apply the principles you have learned, you can handle any situation you may meet. We wish to emphasize that the control chart is a tool to assist those who understand the process. You must not only keep control charts but you must also know why you keep them.

Exercise (670):

1. Complete statements on control charts.
   a. __________ is a characteristic of all things in nature and manufactured products.

   b. The control chart is a way of knowing whether a process is within __________ __________.

   c. $\overline{X}$ stands for the process __________.

   d. A center line which gives you the average of averages is indicated by an __________.

   e. A range chart indicates the difference between the __________ and __________ readings.

   f. A trend is indicated by __________ to ______ points in the same directions.

   g. Replenishment should normally cause an ______ in the level of your plottings.

   h. In any random process, the points will vary above and below the __________.

Bibliography

Books

Feininger, Andreas. *The Perfect Photograph.* New York: Amphoto., 1974.

__________. *Total Picture Control.* New York: Amphoto., 1973.

Kodak Color Dataguide. New York: Eastman Kodak Co., Latest Edition.

Kodak Data Book E-66. *Printing Color Negatives.* New York: Eastman Kodak Co., Latest Edition.

Kodak Data Book 0-4. *Professional Portrait Techniques.* New York: Eastman Kodak Co., Latest Edition.

Rothstein, Arthur. *Photojournalism.* New York: American Photographic Book Publishing Co., Latest Edition.

Department of the Air Force Publications

AFM 52-1, *Ground Cameras and Photo Lab Equipment,* 1 November 1972.

AFM 52-2, Volumes 1 and 2, *Principles and Practices for Precision Photographic Processing Laboratories,* 15 July 1973.

AFR 36-93, *Official Photographs,* 3 July 1975.

TO 00-35D-54, *USAF Materiel Deficiency Reporting System,* 1 December 1972, Change 1, 15 June 1973.

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Answers for Exercises

CHAPTER 1

Reference:

600 - 1. Without a strong point of interest the viewer will not understand the purpose of the photograph.

600 - 2. The three techniques you can use to simplify a photograph are moving closer to the subject; choosing a plain background; and letting the lighting emphasize the subject.

600 - 3. A high horizon line can give the appearance of depth and distance.

600 - 4. The purpose of a leading line is to guide the viewer's eye to the subject.

600 - 5. The subject will appear pretty sharp while the background will be blurred.

600 - 6. Haze in a scenic will give a feeling of depth.

600 - 7. The appropriate use of a filter can prevent the blending of tones that obscure detail.

601 - 1. Diminution is the characteristic of objects in the background looking smaller than those in the foreground even though they are of the same size. Foreshortening is a form of distortion whereby foreground objects appear to be disproportionally large.

601 - 2. Foreshortening can be prevented in portrait work by maintaining a reasonable shooting distance and using a telephoto lens to achieve the appropriate image size.

601 - 3. A view camera with its many adjustments can achieve distortion free images to a degree not possible with other types of cameras.

602 - 1. a. Camera angle is a key factor in how the subject will look. By changing the camera angle, it is possible to have the subject look more imposing or distinctive. It is therefore a good idea to check out the subject from as many angles as possible when you are shooting.
b. All elements in the picture must contribute to the whole. Whenever possible the photographer should adjust the various elements until they make an effective arrangement. When the subject cannot be moved the photographer must rely on camera angle to make an effective composition.
c. Equipment can extend your picture possibilities. Lenses, filters, and lighting equipment can help you achieve the visual result that you want.
d. The point of focus and the degree of depth of field will determine what the viewer will see sharply. This will in turn determine where the picture emphasis will be.
e. The tones of gray and the contrast relationship between them will affect how the viewer sees the picture.

603 - 1. b

603 - 2. c

CHAPTER 2

604 - 1.
a. any.
b. even.
c. 45°.
d. light.
e. bounce; polarized.

605 - 1.
1b
2d
3c
4a

605 - 2. You need to use high-contrast film. High-contrast film is necessary to maintain maximum separation between the white background and the black lines of the line subject.

605 - 3. A dark green filter.

605 - 4. When copying a magazine page you should back it with black paper so the lettering on the back side does not show through.

605 - 5. A blue filter.

606 - 1.
3a
9b
1c
5d

607 - 1. 6" x 8".

607 - 2. 1" x $1\frac{1}{4}$".

607 - 3. Bellows extension = 8 x (1 + 1) = 16 inches
Subject distance = 16 + 1 = 16 inches
Bellows extension factor $= \frac{16 \text{ inches}^2}{8 \text{ inches}^2} = \frac{256}{64} = 4$

f/8 at 1/2 second $(4 \times \frac{1}{8})$

607 - 4. Bellows extension= 12 x (2 + 1) = 36 inches
Subject distance $= 36 + \frac{2}{1} = 18$ inches

Bellows extension factor $= \frac{36 \text{ inches}}{12 \text{ inches}} = 8$
f/11 at 4 seconds

608 - 1.
a. False
b. False
c. True
d. True
e. True

609 - 1.
a. 4 x 5
b. 4
c. 105mm; 135mm
d. self-cocking; 1 second; 1/125
e. 4 150
f. reflex
g. 360

CHAPTER 3

610 - 1. Individual characteristics are molded from biological-genetic, cultural, sociological-economic, and psychological factors.

610 - 2. Two main factors which determine a person's intelligence are the biological-genetic and the environmental.

610 - 3. A race is a group of people with a common physical appearance.
A nationality is a group of people with a common culture.

610 - 4 To be a member of a group you must exhibit its characteristics and be accepted by it.

610 - 5. By being thoroughly professional you can handle each photographic situation you are placed in.

611 - 1. The 5Ws are the who, what, where, when, and why of each event. Who covers the participants. What is the action. Where is the place. When covers the time. Why is the reason for or significance of the event.

612 - 1.
a. Dewey decimal system.
b. ten.
c. seven.
d. title, subject, author.
e. Magazines.

613 - 1. The three factors are product desired, shooting conditions, and time requirement. The product desired will determine the type of film, processing, printing, and camera choice. The shooting conditions will also determine the type of camera and particularly the accessories that will be needed. Time requirements will often call for a particular type of material or limit the number of shots.

614 - 1. A visual check gives you a good indication of the condition and usability of a piece of equipment.

614 - 2. By performing operational checks you better insure that you will not experience a malfunction.

614 - 3. Preventive maintenance prevents excess wear or damage to equipment.

614 - 4. Three preventive techniques are making adjustments, cleaning, and lubrication. Making adjustments is tuning a piece of equipment so it conforms to specifications. Cleaning will help keep down dust or dried chemicals that can ruin any step in the photographic process. Proper lubrication will prevent wear.

614 - 5. Limitations on operator maintenance are set out by applicable regulations and technical orders. They are also affected by the availability of maintenance personnel and maintenance beyond the lab.

615 - 1. A personality portrait should highlight the individual. It is more than a record shot and is often used to highlight the individual's accomplishments.

615 - 2. The three categories are personality portraits, key man, and officer portraits.

615 - 3. Only by keeping up with AFR 36-93 can you be sure that your portraits will conform with the regulation.

615 - 4. You have to exercise tact because you will often have to advise an officer regarding his appearance in terms of conformance with AFR 36-93.

616 - 1.
a. retouched; enlarged
b. freeze
c. eyes
d. limited
e. upper chest
f. 6''
g. one
h. modeling
i. toward
j. away
k. 3:1
l. lighting ratio
m. background
n. hair
o. 8 feet

617 - 1.
1d
2b
3e
4c
5a

618 - 1. A barn door controls spill light and permits complete directional control of the light.

618 - 2. A misfire results in an audible warning and an indicator lights up next to the specific outlet on the power supply unit.

618 - 3. The vertical height of a light unit is controlled by a telescopic riser.

618 - 4. Frayed cords and overloaded circuits are two typical safety hazards.

619 - 1. Identification photography provides the necessary photographs to be used in identification procedures.

619 - 2. Passport pictures must withstand mounting temperatures of 200°F, so they must be printed on good materials.

619 - 3. By having individual passport pictures, each member of the family will have the freedom to travel, which would not be possible with a group picture attached to a single passport.

619 - 4. 45° 1:1 flat lighting is used in identification photography.

620 - 1. Good composition is necessary to attract a reader's attention.

620 - 2. The three basic shots are long, medium, and closeup. The long shot establishes the overall scene. A medium shot moves in to show the subject in its immediate surroundings. The closeup shows story-telling detail.

620 - 3. Timing is necessary to capture the fleeting moments that best tell the story.

620 - 4. The four parts are explanation of the action; identification of persons or objects in the photograph; additional details or background information; and credit line.

620 - 5. Four different methods of identification are action, contrast, elimination, and from left to right.

621 - 1. Repeated identity would be suitable in a story that emphasizes the accomplishment of an individual.

621 - 2. Simple chronology can be used to put together pictures which do not have a direct relationship of one to another other than that they deal with the overall subject. The photographs therefore can simply be put in historical order. With narrative chronology the photographs have a particular story telling sequence which must be followed to impart understanding.

621 - 3. Contrast continuity could be used to show the do's and don'ts of extinguisher use.

622 - 1. A sample shooting script might be as follows:
a. SHOT 1: Medium Shot
An airman is shown asleep in his bed with a lighted cigarette dangling from his hand.
WHY: Establishes the basic problem.
b. SHOT 2: Long Shot
Photograph of a fire engine and ambulance heading toward a barracks.

WHY: Shows the effect of the hazard.

c. SHOT 3: Medium Shot

A covered body is carried on a litter into a waiting ambulance.

WHY: Shows the tragic consequences of the hazard.

623 - 1. Most industrial photographs are used to show objects, processes or the work of individuals.

623 - 2. You must understand a particular industrial process to be able to photograph it effectively.

623 - 3. The total work environment must be shown in an effective manner. Of particular importance is that all safety procedures are being followed. This is necessary to ensure that the shop is shown in good order.

623 - 4. Close-up shots of machines make them appear more impressive.

623 - 5. Silouette lighting emphasizes the shape and form of the subject.

624 - 1. To be an effective sports photographer you must understand the rules of the sport you are covering. Only through this understanding will you know what should be shot to give the telling moments.

624 - 2. A 35mm reflex camera gives the speed, flexibility in choice of lenses and accessories, and film quantity that is necessary in fast action situations.

624 - 3. By knowing the field you will have an idea what camera positions will be available and effective.

624 - 4. First you need to realize that a strobe will be one-fourth as effective when used outdoors or in a big arena because of the absence of reflective surfaces. Secondly, you need to consider that the strobe should not be used if its flash would adversely affect the performance of any of the participants.

625 - 1.
- a. uncontrolled
- b. flash
- c. film
- d. overall
- e. portraits of personnel involved.

626 - 1. 1:1 image size

626 - 2. An extension tube is a rigid tube which fits between the camera body and the lens. The tube therefore changes the effective focal length of the lens to a given degree. A bellows, however, is flexible and may be racked in and out until the image size is the one that is desired. A bellows is therefore more flexible than an extension tube.

626 - 3. Depth of field is limited because the lens-to-subject distance is so close. In addition, a wide open aperture setting is often required for exposure reasons. This, too, limits the amount of depth of field.

626 - 4. A tripod is essential to ensure a very steady camera. Any camera movement would be greatly enhanced in close-up work due to the magnifications involved.

626 - 5. 81 times the given reading ($EF = (M+1)^2$)

$$EF = (8+1)^2$$
$$EF = 9^2$$
$$EF = 81$$

626 - 6. A ring light is effective because it gives very even flat lighting.

627 - 1. Crash or accident photographs help investigators in solving the cause of the incident.

627 - 2. Color may indicate a cause not shown in black and white. For example, colors may indicate the degree of heat that was generated during the incident.

627 - 3. A photographer must not weaken in the face of the tragedy of an accident or crash. He must concentrate on getting the pictures regardless of the hardships that surround him. To do otherwise would make him a problem for the rescue forces.

627 - 4. Crash information can only be released to the official authorities who have a need to know.

627 - 5. Flash may create a fire hazard.

627 - 6. 1. general views of the areas involved; 2. close-up photographs of important details; 3. photographs of specific parts; 4. marks left on the ground; 5. views that show damage to other property.

627 - 7. Vehicle number; make, model, and year of the vehicle; tag number and state.

628 - 1. By bringing the defective part to the lab, you will have a greater choice of equipment, background material, and lighting.

628 - 2. Normally you want to use the finest grain film that you can to insure maximum detail.

628 - 3. A copy camera is ideal for photographing a circuit board.

628 - 4. Chalk is useful in making cracks stand out on a black surface.

628 - 5. Even lighting is used to insure maximum detail.

628 - 6. TO 00-35D-54 is the main TO to consult in regard to UMR work.

629 - 1. Haze causes an overall bluish cast in color photographs and lowers the contrast in both black-and-white and color work.

629 - 2. Crosslighting provides modeling and also cuts down the effect of haze.

629 - 3. Infrared black-and-white film has excellent haze cutting qualities.

629 - 4. A high shutter speed and not supporting the camera with any part of the plane will help reduce the effects of motion.

629 - 5. Good weather conditions for aerial photography are generally considered to be clear with 10 to 15 miles-per-hour winds and visibility of 15 miles or more.

629 - 6. A high wing, fairly slow plane is fine for aerial photography.

629 - 7. A low oblique includes no horizon or sky. Both horizon and sky are included in a high oblique.

630 - 1. f/8.

630 - 2. Depth of field isn't a problem because all shots are made at infinity.

630 - 3. The pilot should bank aircraft and slip it toward the target.

CHAPTER 4

631 - 1. Machine speed is one factor, along with tank accumulation, which determines how long the developer will act upon the material being processed. In fact, feet per minute in machine processing is used in the same manner as development time is used in hand processing.

631 - 2. Machine processing temperatures are usually higher because of the higher operating speeds.

631 - 3. Agitation is essential to insure a continual fresh supply of chemical solution to the emulsion. Improper agitation results in uneven development or fixation.

631 - 4. Developer recirculation could be used to maintain proper temperature, to filter the solution, or as an aid to agitation.

631 - 5. Replenishment is necessary to maintain fresh chemistry.

631 - 6. Too little drying will cause the film to be tacky.

632 - 1.
- a. 8; 7
- b. 7; 2; 3; 2
- c. Developer
- d. 9½; 11 by 14
- e. bullit
- f. 25
- g. Auto
- h. Manual
- i. first
- j. flowmeters
- k. 5
- l. Rings; watches

633 - 1. Keeping the processor clean.

633 - 2. The crossover assemblies and the transport racks above the solution line should be washed daily. The feed rollers of the entrance roller assembly should also be wiped off.

633 - 3. Hot water should not be used because it could damage the polyethylene covered rollers.

633 - 4. You should know when periodic maintenance is to be performed because the machine will have to be shut down, thereby possibly interfering with mission accomplishment.

633 - 5. System cleaner is used to clean out the developer tanks after they have been drained.

633 - 6. You should wear goggles.

633 - 7. You should use warm water to clean out the fixer tank.

634 - 1. Cleanliness is the most important aspect of operator maintenance.

634 - 2. By making a thorough inspection you will prevent mission failures.

634 - 3.
- 1d
- 2a
- 3b
- 4c
- 5e
- 6c

CHAPTER 5

635 - 1.
- a. light
- b. white; ultraviolet; infrared
- c. 400; 700
- d. adaptability
- e. magenta
- f. absorption; reflection
- g. metals
- h. light wave interference
- i. dispersion
- j. Fluorescent
- k. saturation
- l. primary

636 - 1.
- a. three
- b. yellow
- c. magenta, yellow; cyan
- d. blue

637 - 1.
- a. one; two
- b. blue
- c. green; blue
- d. no
- e. magenta; yellow

638 - 1.
- a. three
- b. green
- c. yellow; top; middle
- d. panchromatic; red
- e. top; middle
- f. red
- g. blue
- h. red
- i. red
- j. 3400

639 - 1. The relative humidity should be maintained between 40 and 50 percent.

639 - 2. The temperature should be between 0°F and -10°F.

639 - 3. Improper storage will result in loss of film speed and color balance.

639 - 4. No. Film stored near chemicals is likely to be damaged by chemical vapors.

640 - 1. The exposure latitude of reversal film is 1/2 under to 1/2 over.

640 - 2. The contrast ratio should be maintained at 3:1.

640 - 3. One way to reduce a scene's contrast is to use supplementary lighting.

640 - 4. Underexposure will result in heavy dye densities.

641 - 1.
- a. True
- b. False
- c. False
- d. False
- e. True
- f. False
- g. True

642 - 1.
- a. 80A
- b. 85
- c. 82A
- d. 81A
- e. 81A
- f. FLB
- g. CC30R
- h. 81A
- i. 80C
- j. 82A

643 - 1. Clean, sediment-free water should be used in mixing chemicals.

643 - 2. The water should be set at the recommended temperature for mixing which may be warmer than the temperature used in processing.

643 - 3. Normally the chemicals should be mixed in the order in which they are used.

643 - 4. Proper chemical storage will prevent oxidation.

643 - 5. The best insurance against dermatitis is a program of contact prevention.

643 - 6. Hazardous liquids should be stored on or near the floor.

643 - 7. When your hands get soaked in bleach you should immediately wash your hands.

644 - 1. A negative silver image is formed in the first developer of the reversal process.

644 - 2. Color is achieved through the formation of dyes when the film is processed in a color developer.

644 - 3. The following dyes are formed: yellow dye is formed in the blue sensitive layer; magenta is formed in the green sensitive layer; and cyan in the red sensitive layer.

644 - 4.
- a. Negative silver image.
- b. Positive silver image.
- c. Positive dye image.

644 - 5. No. The amount of dye produced is directly proportional to the number of halides reduced in the color developer. It is therefore the number of halides exposed by reexposure and not camera exposure that determines the dye production.

644 - 6. Yellow and magenta dyes will be formed during processing.

644 - 7. Yellow dye will be formed. With color negative film, dye production is directly related with camera exposure since there is a single, color developer. The blue subject will expose the top layer which in turn produces yellow dye.

644 - 8. In the middle layer a yellow coupler is used and a reddish magenta one is produced in the bottom layer. The colored couplers form a printing mask so that there is consistent light transmission across the entire film and at all layers.

645 - 1. a. First Developer—The first developer is a black-and-white developer which reduces the halides exposed during camera operation into black metallic silver, forming a negative silver image.
b. Reexposure—Reexposure is done by exposing the film to light or by fogging the unexposed halides by chemical means. This reexposure leaves a positive latent image and provides the necessary halides for dye production.
c. Color Development—The color developer reduces the halides exposed during reexposure forming a positive silver image and a positive dye image.
d. Bleach—The bleach step converts all the silver, including the yellow collodial silver layer, into soluble compounds that can be fixed away.
e. Fixing Bath—The fixing bath makes the image permanent by removing any unexposed silver and the silver that has been prepared by the bleach.

646 - 1. a. Color Developer—Converts the exposed silver into a negative silver image and a negative dye image.
b. Bleach—Converts the exposed silver halides and the collodial silver layer into a soluble compound.
c. Fix removes the unexposed silver and that which was prepared by the bleach.

647 - 1. Most color enlargers have a color filter head which would not be found in a black-and-white enlarger. The color filter head is necessary to form the filter packs that are essential in color printing.
647 - 2. The Chromega is a diffusion type enlarger.
647 - 3. The Chromega D-4 can handle negatives up to 4 x 5.
647 - 4. You would use the 105mm lens to print 120 film.
647 - 5. The bellows is raised or lowered by the action of the focusing mechanism.
647 - 6. The purpose of a voltage stabilizer is to keep the voltage going into the enlarger at a constant level. The voltage must be constant to ensure consistent color temperature.
647 - 7. The top layer of color paper records red light and forms cyan dye. The middle layer records green light and forms magenta dye. The bottom layer records blue and produces yellow dye.
647 - 8. It would be recorded in the top and middle layers.
647 - 9. The paper should be allowed to warm up to 70°F.

648 - 1. When employing the additive system three separate exposures using each of the primary filters are made. The white light method uses a single exposure through a subtractive (magenta and yellow) filter pack.
648 - 2. The normal starting pack is 50M and 70Y.
648 - 3. A CP2B filter is always employed in color printing.
648 - 4. a. Subtract 05Y.
b. Add 20 M + 20Y.
c. Add 10Y.
d. Subtract 05M + 05Y.
e. Subtract 20M.

649 - 1. a. Developer—Converts the exposed silver into a positive silver and positive dye image.
b. Bleach-Fix—Converts all silver into a soluble compound which is then dissolved.
c. Stabilizer—Acts as a wetting agent and stabilizes the dyes to prevent fading.

650 - 1. a. Panchromatic emulsion.
b. Wratten 10.
c. light; dark.
d. development.
e. Selectol-Soft.

651 - 1. a. gelatin; optically perfect.
b. blue.
c. Color printing.
d. .30 M; .30 C.
e. green.

652 - 1. a. Etching
b. large
c. reducer
d. steam
e. set
f. small
g. pinholes
h. orange
i. 230°F

653 - 1. a. tape; glass
b. Newton Rings
c. wax
d. slide mounter

CHAPTER 6

654 - 1. A floor should be mopped three times. Once with hot, soapy water; again with clean, clear water; and then a third time with a dry mop.
654 - 2. Rollers should be cleaned to prevent chemical buildup which can scratch or, in extreme cases, tear film.
654 - 3. If spilled chemicals are left to dry on the floor, they will assume a powdery form that can become stirred up.

655 - 1. a. air, moisture, heat
b. cyanide gas
c. oxidize
d. ground
e. Chemical

656 - 1. a. Overexposure.
b. Overexposure.
c. Hazy negatives can be caused by: sun shining into the lens; a dirty lens; overexposure, or fogging.
d. Reticulation.
e. Hypo in the developer or a brief exposure to light during development.
f. Air bubbles on the film during fixing.
g. Chemical or light fog.
h. Lack of agitation in an acid stop bath.

657 - 1. In terms of mathematics, pH is the logarithm of the reciprocal of the hydrogen ion concentration in a solution. In terms of the pH scale, it is a measurement of the acidity, alkalinity or neutrality of a solution. 0-6.9 represents the acid level, 7 is neutrality, and 7.1 to 14 represents alkalinity.

658 - 1. pH is an indicator of the potential activity of the solution. A low pH would show a low performance potential resulting in inadequate development. Too high of a pH would indicate overactivity which could cause damage to the material or excessive contrast.

658 - 2. Starting at a pH value of about 3.5 and working upward, the hardening action increases. Hardening reaches its peak at about 5.0 and then decreases rapidly.

658 - 3. The washing rate is increased with a slight rise in pH.

659 - 1. Litmus paper is used to identify whether a solution is an acid or a base. Blue litmus changes to red when in an acid solution and red litmus turns blue in an alkaline solution.

659 - 2. The two transition points are 5 and 12.

659 - 3. Red.

659 - 4. Green.

660 - 1.
a. reference
b. KCL (potassium chloride)
c. glass
d. Buffer
e. 9
f. acid
g. standby
h. buffer
i. distilled
j. expanded
k. electrodes

661 - 1. Specific gravity is defined as the ratio of the mass of a given volume of a substance to an equal volume of distilled water at the same temperature.

661 - 2. Specific gravity is an indicator to see if the chemistry has been properly mixed.

661 - 3. A specific gravity reading which is too high would indicate too much of the ingredients, foreign ingredients, or not enough water.

661 - 4. A hydrometer is calibrated to read 1.00 in pure, distilled water at 60°F.

661 - 5. 0.006 must be added to the reading.

661 - 6. You read the value at the top of meniscus.

662 - 1. Certifying a developer involves three steps: measuring specific gravity, pH, and sensitometry. Specific gravity indicates whether the solution is properly mixed. pH indicates the strength or activity. Sensitometry will give visual evidence (test strip) of the developer's performance.

663 - 1.
a. intensity
b. electronic flash
c. meter candle seconds
d. attenuators
e. repeatability

664 - 1.
a. Photoelectric; visual comparison
b. four
c. Gold
d. red, green, blue
e. calibration
f. replicate

665 - 1. A logarithm is a number used to represent another number.

665 - 2. There are two parts to a logarithm: the characteristic and the mantissa.

665 - 3. The mantissa is always positive.

665 - 4. Common logarithms are based on 10.

665 - 5. A negative characteristic is indicated by a — (bar) over the number.

665 - 6. The characteristic is determined by inspection. '

665 - 7.
a. 2
b. 0
c. $\overline{4}$
d. $\overline{1}$
e. 1

665 - 8.
a. 4771
b. 7404
c. 7782
d. 8451
e. 6474

665 - 9.
a. $\overline{2}.0000$
b. 1.2900
c. $\underline{5}.8209$
d. $\overline{6}.6990$
e. 0.9031

665 - 10.
a. 153
b. .00107
c. 76.3
d. .552
e. 7.95

666 - 1. The vertical axis charts changes in density, whereas the horizontal axis charts changes in exposure.

666 - 2. You first take the log of intensity and add it to the log of time which gives you the log of exposure at the plane of the sensitometer. From this total you subtract the log of the density of the step you are calculating. The result is the log of exposure of the step.

666 - 3. Each axis is marked off in increments of 0.20.

666 - 4. The vertical axis represents the density of the test strip you are plotting and the horizontal axis represents the density of original (standard).

666 - 5. The toe section is defined as a region of unequal rise because the density does not increase equally for an equal increase in exposure.

666 - 6. The threshold marks the beginning of the toe section. It represents the least amount of light that is required to produce a density which is perceptible.

666 - 7. The straight line portion represents the area of proportional brightness representation or correct exposure.

666 - 8. The highlights are recorded in the shoulder part.

666 - 9. The latitude of an emulsion is the exposure range over which a proportional relationship between density differences and exposure differences is obtained. In other words, it is the range of exposures represented by the straight line portion of the characteristic curve.

666 - 10. Useful exposure covers all of the straight line portion and parts of the toe and shoulder.

666 - 11. Gamma is a sensitometric quantity standing for the slope, or gradient, of the straight-line portion of the characteristic curve of photographic emulsions.

666 - 12. Extend the straight line to the horizontal axis and then move to the right a distance of 1.00. Construct a vertical line to intersect the straight line portion of the curve. Then read the value off the vertical axis that corresponds to that point.

666 - 13. Gamma is primarily an indication of contrast and therefore is the result of the degree of development.

666 - 14. Extreme overdevelopment will cause an increase in the fog level.

667 - 1. The four factors are chemical reaction of the developing solution with the silver halides of the emulsion; action of the air upon the solution; loss of solution through carryover to the following tank; and dilution of the developer.

667 - 2. The most significant byproducts are bromides and iodides. They both have a restraining effect on development.

667 - 3. Sensitometric testing, because such testing shows you the results that are being produced by your developer.

667 - 4. The normal parts are reducing agents, sodium sulfite, an alkali, and water.

667 - 5. Rate of replenishment is normally related to the amount of film (material) being processed.

667 - 6. By removing some of the solution you will better ensure that you will not overflow the tank. You can then pour back a sufficient amount of the old solution to top the tank.

667 - 7. End point of replenishment is reached when the solution is so contaminated with impurities that it may cause image deterioration.

668 - 1. The two functions are to minimize or stop the action of the developer and to prolong the life of the fixing bath.

668 - 2. As the stop bath is used, the acid of the bath is neutralized by the carryover of alkaline developer into the stop bath solution. The reaction byproducts are insignificant, but the drop in acidity tends to make the stop bath ineffective.

668 - 3. Deterioration of a chrome-alum stop bath is accompanied by a color change from purple to a yellowish green.

668 - 4. It should be maintained at a pH of between 4.0 and 5.0.

668 - 5. You can replenish the stop bath by adding appropriate amounts of a strong solution of acetic acid.

668 - 6. The end point of replenishment occurs when there is a sufficient accumulation of foreign matter in the bath to possibly damage the photographic image.

668 - 7. Continuous replenishment is used in conjunction with continuous processing machines.

669 - 1. Carryover of previous solutions into the fixing bath and carryover of the fixing bath changes the fixing bath activity. The carryover of previous solutions dilutes the chemical components of the fixing bath and carryover into the wash depletes the chemical components of the bath.

669 - 2. The four chemical reactions are complex silver compounds called argentothiosulfates are formed; neutral salts are formed; iodide is liberated; and there is loss of sulfite.

669 - 3. The four stages are drop in acidity; loss of hardening properties; clearing time increases; and finally, complex thiosulfates are formed which are insoluble and cause image deterioration.

669 - 4. Effective replenishment should be connected with a silver recovery program.

669 - 5. The replenishment process is ultimately limited by the accumulation of iodide in the bath.

670 - 1.
  a. Variability
  b. statistical control
  c. average
  d. $\overline{X}$
  e. high; low
  f. 5; 7
  g. increase
  h. process average

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STOP– **1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.** **2. USE NUMBER 1 OR NUMBER 2 PENCIL.**

23132 04 21

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
PHOTOGRAPHIC APPLICATION

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that numerical sequence on answer sheet alternates across from column to column.
3. Use a medium sharp #1 or #2 black lead pencil for marking answer sheet.
4. Circle the correct answer in this test booklet. After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'TS:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #1 or #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed*. Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (600) To be effective, every photograph should have a definite

a. tonal scale.
b. point of interest.
c. depth of field.
d. color balance.

2. (600) The leading line on a photograph guides the viewer to the

a. point of interest.
b. horizon line.
c. frame.
d. edge of the composition.

3. (600) Which technique is used to make a moving subject appear sharp but the background blurry?

a. Stop action.
b. Perspective control.
c. Field of focus.
d. Panning.

4. (600) The depicting of a three-dimensional subject on a two-dimensional surface is defined as

a. perspective.
b. illusionism.
c. foreshortening.
d. counterpoint.

5. (600) What three compositional devices are used to create a feeling of depth in a photograph?

a. Line, figure, and texture.
b. Figure, texture, and haze.
c. Texture, haze, and line.
d. Haze, line, and figure.

6. (601) In photography work, the convergence of parallel lines are accepted in the

a. horizontal.
b. diagonal.
c. vertical.
d. spectral.

7. (602) By shooting down on your subject, you will make the subject appear

a. larger.
b. more imposing.
c. smaller.
d. significant.

8. (603) To be an effective communicator of photography, the photographer must best understand the

a. receiver.
b. props.
c. visual symbols.
d. English language.

9. (604) At what angle are lights positioned for copying glossy subjects?

a. 25°.
b. 45°.
c. 75°.
d. 95°.

10. (605) If you are copying a black-and-white print with a blue stain, what type filter would be used?

a. Green.
b. Red.
c. Yellow.
d. Dark blue.

11. (605) If you are copying a black-and-white print that has faded yellowish-brown you should use which filter?

a. Blue.
b. Red.
c. Green.
d. Yellow.

12. (606) When copying color photographs in black-and-white, you should use what type of film?

    a. Ultraviolet.
    b. Panchromatic.
    c. Blue-sensitive.
    d. Orthochromatic.

13. (607) When using a 10-inch lens, what bellows extension is needed to make a 25 percent reduction?

    a. 18 inches.
    b. 12 1/2 inches.
    c. 16 inches.
    d. 10 inches.

14. (607) What would the bellows extension factor be if your bellows extension was 10 inches and the focal length of your lens was 5 inches?

    a. 1.
    b. 2.
    c. 3.
    d. 4.

15. (608) When copying color slides, the duplicate is likely to have more

    a. detail.
    b. fine grain.
    c. contrast than the original.
    d. saturation than the original.

16. (609) When using the MP-4, the image will appear

    a. reversed.
    b. inverted.
    c. curvilinear.
    d. distorted.

17. (610) Biological-genetic factors which contribute to individual characteristics include

    a. sex, race, and customs.
    b. race, customs, and intelligence.
    c. customs, intelligence, and sex.
    d. intelligence, sex, and race.

18. (611) The 5Ws of journalism include

    a. who, wonder, and what.
    b. wonder, what, and where.
    c. what, where, and who.
    d. where, who, and wonder.

19. (612) Photography would be found under what Dewey decimal classification?

    a. 300—Social Sciences.
    b. 500—Pure Science.
    c. 700—Fine Arts.
    d. 900—History.

20. (612) The following are all types of card catalogs except

    a. author cards.
    b. title cards.
    c. subject cards.
    d. category cards.

21. (613) An architectural assignment normally calls for what kind of camera?

    a. View.
    b. Press.
    c. 35mm reflex.
    d. Twin-lens reflex.

22. (614) Preventive maintenance includes all of the following except

    a. lubrication.
    b. disassembly.
    c. cleaning.
    d. making adjustments.

23. (616) When using broad lighting, the main light fully illuminates

a. from underneath the face.
b. the front of the face from a high angle.
c. the side of the face turned toward the camera.
d. the side of the face turned away from the camera.

24. (616) When making a portrait, the light closest to the camera normally acts as what kind of a light?

a. Hair.
b. Main.
c. Back.
d. Fill.

25. (616) Which one of the following lighting ratios is routinely used to turn out high quality portraits?

a. 3:1.
b. 6:1.
c. 1:1.
d. 8:1.

26. (617) What type of lighting should be used when photographing a broad-faced subject?

a. Short.
b. Glamour.
c. Broad.
d. Cross.

27. (618) A misfire, when using "Ascor" series 360-1 lighting, results in

a. an audible warning.
b. a blown fuse.
c. a repeating flash.
d. flashing red lights.

28. (619) All of the following applies to the production of passport pictures except that

a. color film is used.
b. 35mm reflex cameras are used.
c. photographs are made in duplicate.
d. prints must withstand a high temperature.

29. (620) All of the following techniques are used in identifying participants in a caption except

a. contrast.
b. action.
c. elimination.
d. right to left.

30. (621) Which type of continuity requires a definite sequence?

a. Narrative chronology.
b. Repeated identity.
c. Contrast continuity.
d. Parallel continuity.

31. (622) The first part of a shooting script is concerned primarily with

a. sequence of shots.
b. general ideas.
c. shooting angle.
d. shooting position.

32. (623) To be an effective industrial photographer, it is most important that you

a. understand abstract photography.
b. know how to editorialize the subject.
c. know how to operate an industrial camera.
d. understand the industrial process you are photographing.

33. (624) What type of camera attachment is used to shoot photo sequences?

a. Rangefinder focusing.	c. Telephoto lens.
b. Motor drive.	d. Sequence lens.

34. (625) All of the following applies to combat photography except the need to carry

a. lightweight flash equipment.	c. a good supply of film.
b. military gear.	d. simple tools for camera repair.

35. (626) Which of the following attachments permits the most versatility in establishing a given image size?

a. Extension tubes.	c. Macro lens.
b. Close-up attachments.	d. Bellows.

36. (626) For a 5 times magnification of the subject, your exposure would have to be increased by what factor?

a. 25X.	c. 20X.
b. 36X.	d. 5X.

37. (627) The main purpose of accident photography is to

a. help investigative personnel.
b. furnish support data in civil suits.
c. provide photographs for safety campaigns.
d. provide material for the Airman magazine.

38. (628) Which camera is the most suitable for unsatisfactory material report photography?

a. View.	c. 35mm Reflex.
b. Press.	d. 35mm Rangefinder.

39. (628) Which technical order should you consult concerning unsatisfactory material report work?

a. 00-1686-5.	c. 00-09C-95.
b. 00-35D-54.	d. 00-1035-28.

40. (629) The type of black-and-white film that has the best haze cutting qualities is

a. panchromatic.	c. infrared.
b. Ektachrome.	d. blue-sensitive.

41. (629) Which type of oblique aerial photograph does not include sky or horizon?

a. Low.	c. High.
b. Three-quarter.	d. Perspective.

42. (630) When doing aerial photography, you need not be concerned with

a. exposure.	c. type of camera.
b. depth of field.	d. choice of film.

43. (631) In machine processing, feet per minute can be compared with what factor in hand processing?

a. Agitation.	c. Time.
b. Temperature.	d. Solution activity.

44. (631) To maintain proper solution strength, what system is used with continuous processing equipment?

a. Recirculation.
b. Tank turbulation.
c. Replenishment.
d. Gaseous burst.

45. (632) The maximum speed of the Versamat 11C-MW is how many feet per minute?

a. 10.
b. 15.
c. 20.
d. 25.

46. (632) The replenishment rates on a Versamat 11C-MW are set by

a. replenisher switches.
b. recirculation pumps.
c. flow meters.
d. fixer-developer switches.

47. (633) Kodak Developer System Cleaner must be handled carefully because it contains

a. sulfuric acid.
b. boric acid.
c. sulfamic acid.
d. cyanide.

48. (634) What is the most important aspect of operator maintenance on photographic equipment?

a. Disassembly.
b. Lubrication.
c. Redesign.
d. Cleanliness.

49. (635) The optical spectrum includes all of the following except

a. ultraviolet.
b. infrared.
c. X-rays.
d. white light.

50. (635) Selective reflection is a characteristic most often displayed by certain

a. plastics.
b. woods.
c. papers.
d. metals.

51. (635) The ability of a material to absorb radiation of one wavelength and re-radiate it at another is called

a. dispersion.
b. fluorescence.
c. refraction.
d. electromagnetism.

52. (635) The major deficiency of Maxwell's system of color production was the

a. use of additive filters.
b. need for dye transfer.
c. use of subtractive filtration.
d. lack of permanence.

53. (636) The subtractive primary colors are

a. magenta, cyan, and yellow.
b. blue, yellow, and cyan.
c. red, green, and blue.
d. red, magenta, and blue.

54. (635) If equal parts of green, blue, and red light are projected from three light sources and then superimposed, what type of light will be produced?

a. Black.
b. Magenta.
c. White.
d. Blue.

55. (637) A combination of cyan and magenta filters over a single light source would pass what color of light?

a. Red.
b. Green.
c. Blue.
d. Yellow.

56. (638) The middle layer of color film is designed to record what color of light?

a. Red.
b. Green.
c. Blue.
d. Yellow.

57. (638) Zero kelvin is based on

a. -273° C.
b. 68° F.
c. 100° C.
d. 212° K.

58. (638) Tungsten color film is particularly sensitive to what color of light?

a. Red.
b. Blue.
c. Green.
d. White.

59. (639) To keep color film for longer than six months, it should be stored at a temperature of about

a. 70° F.
b. 50° F.
c. 25° F.
d. 0° F.

60. (641) Type S Vericolor II film is balanced for what type of lighting?

a. Clear flash.
b. Tungsten.
c. Photofloods.
d. Daylight.

61. (642) To use tungsten color film under daylight conditions, you need which filter?

a. 85.
b. 85A.
c. 85B.
d. 85C.

62. (643) All of the following should be observed when mixing color chemistry except

a. following manufacturer's directions.
b. mixing in stainless steel mixing tanks.
c. using water with not more than 5 percent iron content.
d. mixing the chemicals in the order in which they are used.

63. (644) Color dyes are released in which step of color processing?

a. Bleach.
b. Clearing bath.
c. Color developer.
d. Stabilizer.

64. (644) What type of coupler is used in the bottom layer of color negative film?

a. Clear.
b. Yellow.
c. Reddish magenta.
d. Cyan.

65. (645) The first developer in reversal color processing produces what type of image?

a. Color negative.
b. Latent positive.
c. Dye positive.
d. Black-and-white negative.

66. (645) Reversal exposure forms what kind of latent image?

a. Positive.
b. Color dye.
c. Negative.
d. Collodial.

67. (645) Which reversal processing step converts all the silver into a soluble compound?

a. Stabilizer.
b. Wash.
c. Fixing bath.
d. Bleach.

68. (647) What type of an enlarger is the Chromega D-4 projection printer?

a. Diffusion.
b. Point source.
c. Condenser.
d. Fluorescent.

69. (647) The three filter wheels on the Chromega D-4 handle what colors?

a. Red, green, blue.
b. Red, yellow, green.
c. White, yellow, blue.
d. Cyan, magenta, yellow.

70. (647) What color dye is formed in the middle layer of color paper?

a. Cyan.
b. Yellow.
c. Magenta.
d. Orange.

71. (648) What type of exposure is used in the majority of Air Force color printing?

a. White light.
b. Tricolor.
c. Additive.
d. Halogen.

72. (649) When tray processing color prints with Ektaprint 3 chemistry, gloves should be worn because the chemicals are

a. hot.
b. toxic.
c. smelly.
d. cold.

73. (649) What type of Wratten safelight can be used when you color print?

a. OC.
b. OA.
c. 10.
d. CP.

74. (650) All of the following developers can be used with Panalure paper except

a. Dektol.
b. CP-5.
c. D-72.
d. Selectol-Soft.

75. (651) Most modern color printers use what type of filter in their color head?

a. CC.
b. FLB.
c. CP.
d. FLD.

76. (652) To correct an off-color yellow area on a color print with the dry dye technique, you would use what color dye?

a. Magenta.
b. Purple.
c. Red.
d. Yellow.

77. (652) To make dry dye permanent, you use

a. reducer.
b. fixative.
c. steam.
d. Photo-Flo.

78. (652) To dry mount color prints, the mounting temperature should not exceed

a. 180° F.
b. 200° F.
c. 230° F.
d. 250° F.

79. (653) The most durable slide mount is a combination of

a. tape and glass.
b. metal and glass.
c. plastic and glass.
d. cardboard and plastic.

80. (653) To clean a glass mount, you should use

a. tri-sodium phosphate.
b. commercial glass cleaner.
c. newtonian suds.
d. detergents with wax.

81. (654) What is the most important aspect of photographic quality control?

a. Sensitometry.
b. Cleanliness.
c. Densitometry.
d. Chemical analysis.

82. (655) Most chemicals are affected by all of the following except

a. cold.
b. moisture.
c. air.
d. heat.

83. (655) If you leave chemicals in a partially filled jar, they are likely to become

a. toxic.
b. oxidized.
c. stronger.
d. addictive.

84. (656) Muddy prints are most likely a result of

a. overexposure.
b. overdevelopment.
c. underexposure.
d. underdevelopment.

85. (656) Grayish whites in a print are likely to be caused by

a. insufficient agitation in the stop bath.
b. underexposure and forced development.
c. light fog.
d. reticulation.

86. (657) A pH of 6 indicates what kind of solution?

a. Acid.
b. Water.
c. Alkaline.
d. Base.

87. (657) A pH of 7 indicates what kind of solution?

a. Acid.
b. Neutral.
c. Alkaline.
d. Base.

88. (658) The hardening action of a potassium alum fixing bath is best at what pH factor?

a. 3.
b. 4.
c. 5.
d. 6.

89. (658) The normal pH range of a chrome alum fixing bath is

a. 3 to 4.
b. 4 to 5.
c. 5 to 6.
d. 6 to 7.

90. (659) Blue litmus paper turns red in what kind of solution?

a. Base.
b. Acid.
c. Neutral.
d. Refined.

91. (660) When using a pH meter, pH is measured with which electrode?

a. Thermal.
b. Reference.
c. Electrostatic.
d. Glass.

92. (660) The reference electrode on a pH meter contains which chemical?

a. Sodium sulfate.
b. Potassium bromide.
c. Potassium chloride.
d. Diafine.

93. (661) Specific gravity is normally measured with what instrument?

a. Specific gravity meter.
b. Densitometer.
c. Potentiometer.
d. Hydrometer.

94. (661) When taking a specific gravity, how much must be added to your reading for each 5° F. increase over standard temperature?

a. .0001.
b. .001.
c. .01.
d. .1.

95. (662) A pH reading indicates whether the solution has the

a. proper strength.
b. proper mixture.
c. correct gamma.
d. adequate density.

96. (663) An intensity scale sensitometer is preferred over a time scale sensitometer primarily because it

a. determines gamma.
b. is easier to use.
c. better handles slow-speed film.
d. better duplicates a camera exposure.

97. (664) When zeroing the TD-102 densitometer for black-and-white film readings, the gold filter trim should be

a. placed in the top position.
b. turned counterclockwise.
c. in the bottom position.
d. clockwise.

98. (665) Common logarithms use the base number of

a. 1.
b. 10.
c. 100.
d. 1,000.

99. (665) What part of a logarithm is always positive?

a. Given number.
b. Characteristic.
c. Mantissa.
d. Caret.

100. (665) What is the logarithmic characteristic of 95.6?

a. 0.
b. 1.
c. 2.
d. 3.

101. (665) What is the logarithmic characteristic of 0.0004?

a. $\bar{1}$.
b. $\bar{2}$.
c. $\bar{3}$.
d. $\bar{4}$.

102. (666) What part of the characteristic curve is the beginning of the threshold?

a. Soulder.
b. Inertia point.
c. Straight line.
d. Toe.

103. (666) Highlight density would be found in what part of a characteristic curve?

a. Toe.
b. Straight line.
c. Base plus fog.
d. Shoulder.

104. (666) Gamma is found on what part of the characteristic curve?

a. Straight line.
b. Shoulder.
c. Toe.
d. Inertia point.

105. (667) Chemical changes in a developing solution are the result of

a. oxidation, dilution, and gamma radiation.
b. dilution, gamma radiation, and chemical reaction.
c. gamma radiation, chemical reaction, and oxidation.
d. chemical reaction, oxidation, and dilution.

106. (667) What is the easiest method for detecting the deterioration of a development solution?

a. Sensitometry control strip test.
b. Specific gravity test.
c. pH measurement.
d. Solution analysis.

107. (667) All of the following chemicals could be used in a developer replenisher formula except

a. water.
b. sodium sulfite.
c. sodium carbonate.
d. potassium bromide.

108. (668) When a chrome alum stop bath deteriorates, it changes to what color?

a. Purple.
b. Orange.
c. Pink.
d. Yellowish green.

109. (669) The first property of a fixing bath to change significantly is the

a. clearing time.
b. acidity.
c. hardening property.
d. color.

110. (669) The useful life of the fixing bath is ultimately limited by the accumulation of what chemical?

a. Bromide.
b. Iodide.
c. Acetic acid.
d. Sodium sulfite.

111. (670) Variance is a mathematical expression used to describe the measurement of

a. frequency distribution.
b. the normal curve.
c. variability.
d. periodic sampling.

112. (670) When variations fall within a prescribed percentage of our predictions, we have a

a. Kurtotic process.
b. constant cause system.
c. computer controlled process.
d. system out of control.

113. (670) A chart that is an average of averages is indicated by what symbol?

a. X.
b. $\overline{X}$.
c. $\overline{\overline{X}}$.
d. XX.

114. (670) When plotting a chart, how many points in the same direction indicates a trend signifying that other tests should be conducted?

a. 2-5.
b. 3-7.
c. 4-9.
d. 5-12.